

EXHIBIT 5

AN INTRODUCTION TO DISASTER PSYCHOLOGY

USNRDL Reviews and Lectures No. 4, September 8, 1955, by W. E. Strobe

MILITARY EVALUATIONS GROUP

UNITED STATES NAVAL RADIOLOGICAL DEFENSE LABORATORY

SAN FRANCISCO, CALIF.

AN INTRODUCTION TO DISASTER PSYCHOLOGY¹

By Walmer E. Strobe²

In 1917 an ammunition ship blew up in the harbor of Halifax, Nova Scotia. The ship contained 3,000 tons of TNT. In the terminology of the atomic era, this would be called a 3-kt detonation. Of course, it was a conventional explosion with none of the radiological implications of atomic attack.

Nonetheless, the blast was devastating to the port city of Halifax. The northern part of the city was destroyed, more than 1,800 people were killed, approximately 20,000 others were injured, and many more thousands were rendered homeless in the dead of winter.

There were several official reports of inquiries into the causes and effects of the Halifax explosion. Sociologists and other scholars also studied various aspects of the disaster. These reports are united upon one fact. They each note with some surprise the magnificent performance of a small group of people, who were among the heroes of the Halifax disaster.

This group of people quickly went to the aid of the survivors, organizing the first relief station at Halifax. This was in operation by noon of the day of the disaster. Who were these people? And why was their heroism thought to be unusual?

They were a company of traveling actors who were performing at the local opera house at the time of the explosion. In 1917, the acting profession was not considered to be a particularly useful and acceptable part of society. Actors were generally held to be rather peculiar, somewhat irresponsible, and thoroughly self-seeking. Why, then, did a troupe of actors become heroes when a major disaster visited the city? At the time, no one knew.

PEOPLE ARE MOMENTARILY STUNNED BY AN UNSTRUCTURED SITUATION

People at Texas City, for example, spoke of being frozen into momentary immobility, of not knowing what had happened, or what to do next. A study³ of the Texas City disaster reaches the following conclusions: "The shattering of normal expectations by an unexpected event presents the individual with an unstructured, undefined situation in which he does not know what to do." The shock reaction at Halifax has been described⁴ as "being suddenly stricken with blindness and paralysis." Some of this sensation of disability and helplessness may be due to physical forces such as blast concussion and the like, but the effect of "stun" is also seen in people who are not subjected to any physical force. It is therefore more probable that it is purely psychological and is to be explained in terms of the unexpected and undefined nature of the situation.

¹ From notes of lecture given by author. The lecture notes reproduced herein are based on the research and findings of various investigators in the field of disaster psychology. Acknowledgment is given to these investigators, especially to the authors of the publications listed in the footnotes.

² Head, Military Evaluations Group, U. S. Naval Radiological Defense Laboratory, San Francisco 24, Calif.

³ ORO-T-194, A Study of the Effect of Catastrophe on Social Disorganization, Logan, Killian & Marrs (1951). (The rationale of this paper is drawn from pp. 94-96 and pp. 102-109 of the above reference.)

⁴ S. H. Prince, Catastrophe and Social Change, vol. XCIV of Studies in History, Economics, and Public Law, Columbia University, 1920.

The Mann Gulch fire of 1949 was a forest-fire disaster in which 13 firefighters lost their lives. They were a group under the leadership of a man named Dodge, who, when it became evident that the group was trapped, set a small escape fire in the meadow. The escape fire created a burned area within which Dodge survived although the rest of the group failed to follow him. The report of the board of review⁶ states:

"The evidence is not conclusive as to how many of the crew understood Dodge's purpose in setting the escape fire and heard his directions to join him inside the burned area. The situation was complicated by the noise of the main fire and possibly by the remark of one victim, as heard by some of the men, 'To hell with this, I am getting out of here.' Evidently each individual followed either his own interests at this point or the example of those ahead of him who were making their way up or across the slope."

"Dodge showed coolness and good judgment in setting the escape fire. Both survivors and Sylvia said they believed that all the men would have been saved if they had followed Dodge's lead in getting into the area burned by the escape fire."

This indeed is one of the major problems with which any atomic defense or disaster organization is faced. We know that role persons will arise in the situation. We know that some of these people will be playing roles that are highly desirable. We know that others may be playing roles that are going to increase the loss of life or are likely to interfere with the saving of life by others. A major effort must be made to assure that the roles that people play are those that are the proper ones in the total situation. Such an effort must also include role persons of the highest degree. For example, it has been stated that doctors are generally role persons. They will treat injured persons wherever they find them, irrespective of their own safety or thoughts about their loved ones. But this may not be the role that we would like to have a doctor play. It might be better for him to go immediately to a first-aid collecting station or a hospital where he can treat a vastly greater number of injured in the same period of time and with more effectiveness than he would be able to do in scrambling through the ruins. If this is the case, then the doctor must be trained to the proper role. He must be convinced that the proposed role is the best for him. Once he is convinced of this, it will guide his actions as a role person.

Other examples of improper roles have occurred in civil disasters. In one tornado incident, the police chief, rushing from his home toward his office, stopped on the main business street and became a mere guard, protecting the stores there from looting. The sheriff became directly involved in rescue work as a worker since several branches of his family had lived in the path of the tornado. These men played useful roles but they failed to assume the position of leadership for which they were qualified and which would have resulted in more effective disaster control.

Effective atomic defense will depend in large measure upon the number and type of role persons involved in the emergency. Effective leadership is more important than facilities or equipment. There is rarely anything needed in a disaster area that isn't already there—hardware stores full of tools, acres of abandoned vehicles, grocery stores full of food, department stores, hotels and motels, gas stations full of gas. What is usually in short supply are people who understand the jobs to be done and who do them.

It is interesting that military organizations have developed the role person concept to a high degree, perhaps without realizing it. Compared with civil populations, the military are therefore highly immune to disasters. Not only is the organization able to take advantage of the basic human motivations in disaster, but there is a constant program in the military forces to develop every individual in the organization as a role person. The program starts with basic training and proceeds through successive stages by which men are trained to play particular roles under adverse circumstances.

There are degrees of role persons, and the military recognize this fact. When men are put into the front lines for the first time, the Army is usually careful

⁶ Report of Board of Review, Mann Gulch Fire, Helena National Forest, August 5, 1949, U. S. Forest Service.

to intersperse these green personnel among units that have combat experience. In this case, the combat veterans act as role persons and have a controlling influence in the action that ensues.

It would be an ideal state of affairs if an atomic attack we could have every person a role person playing a proper role. At the present time, this is far from the case and perhaps a more practical target should be proposed. As a rule of thumb, it may be said that if one can be sure that 1 person in 10 in a disaster area will act as a proper-role person, then control of the situation and maximum saving of life and property can result. That is, each role person can take with him, on the basis of silent leadership and example, something of the order of 10 other persons who otherwise might be doing nothing, doing the wrong things, or blindly attempting to escape a situation in which they can see no hope. Of course, it would be desirable to have more role persons than 1 in 10. Therefore, atomic defense organizations should aim at creating as many role persons as possible. Only in this way can we be sure that our people will have the maximum chance of survival.

Now let us return to the city of Halifax and the members of the Academy Stock Co. Why were these play actors heroes at Halifax? Why were they role persons? Regardless of their other traits, actors are trained intensively in playing roles. Each evening they become another person. The degree to which they do become another person indicates their stature as an actor. One cannot know whether these actors had ever acted in a play involving a natural disaster but certainly they were adept at playing roles. When the disaster occurred, it was their natural impulse to play a role. The role they chose as a group to play turned out to be very excellent. Prince says, "Thus it came about that the soldiers, firemen, and play actors may be called the disaster protocracy. They were 'the alert and effective,' the most promptly reacting units in emergency."

Some conclusions with regard to atomic defense are warranted. Certainly one of the principal jobs is to create a large number of role persons and to train them to play the roles that are found to be the most important. While limited numbers of personnel are being organized and trained intensively, the broad base of the population should be indoctrinated with sufficient knowledge to encourage proper structuring of the situation. They should be exposed to the bare essentials regarding emergency action to save life—fighting fires, conducting rescue, and so on.

Existing primary groups at work locations, at home, and at school should be utilized in organizing for atomic defense. Supervisors, family heads, and teachers should be singled out for development into role persons. Their training must be such as to assure maximum protection and control of members of the group and to instill confidence in group members that control leadership will preserve life.

The immediate value of an organization in time of disaster is the ability to structure the situation more adequately and more quickly than the individuals involved. The magnitude of atomic effects makes this function particularly important. Communications are therefore essential to organized atomic defense. If the control center is not provided with the means of acquiring the necessary information on the nature and extent of the disaster, it may form a more erroneous structure of the situation than many subordinate elements or persons who are directly involved. In this event, attempts to control the actions of others will be fruitless. People involved in the disaster will usually ignore nonsensical instructions—instructions which patently are not in accord with the situation.

Of equal importance is the provision of adequate communications for the dissemination of a structure to the whole target population. It is not enough to advise a limited organization while the vast majority of the survivors are forming their own structure and proceeding to act accordingly.

Finally, all disaster organizations should be open-ended; they must not be conceived as a closed corporation. Members of atomic defense organizations should all be trained as leaders. They should be alert to recognize emergent-role persons in a disaster and quick to accept and utilize their valuable efforts. Any disaster plan that depends entirely upon the predisaster organization is a bad plan. The door must be left open for nonmembers to help. When the chips are down, they will help—better than many.

W. E. STROPE.

EXHIBIT 3**RADIOLOGICAL DEFENSE MEASURES AS A COUNTERMEASURE
SYSTEM**

Research and Development Technical Report USNRDI-TR-74, NS083001,
February 15, 1956, by W. E. Strobe

General, Technical Objective AW-5c

Military Evaluations Group

W. E. Strobe, Head

Scientific Director, P. C. Tompkins

Commanding Officer and Director, Capt. R. A. Hinnners, United States Navy

UNITED STATES NAVAL RADIOLOGICAL DEFENSE LABORATORY

SAN FRANCISCO, CALIF.

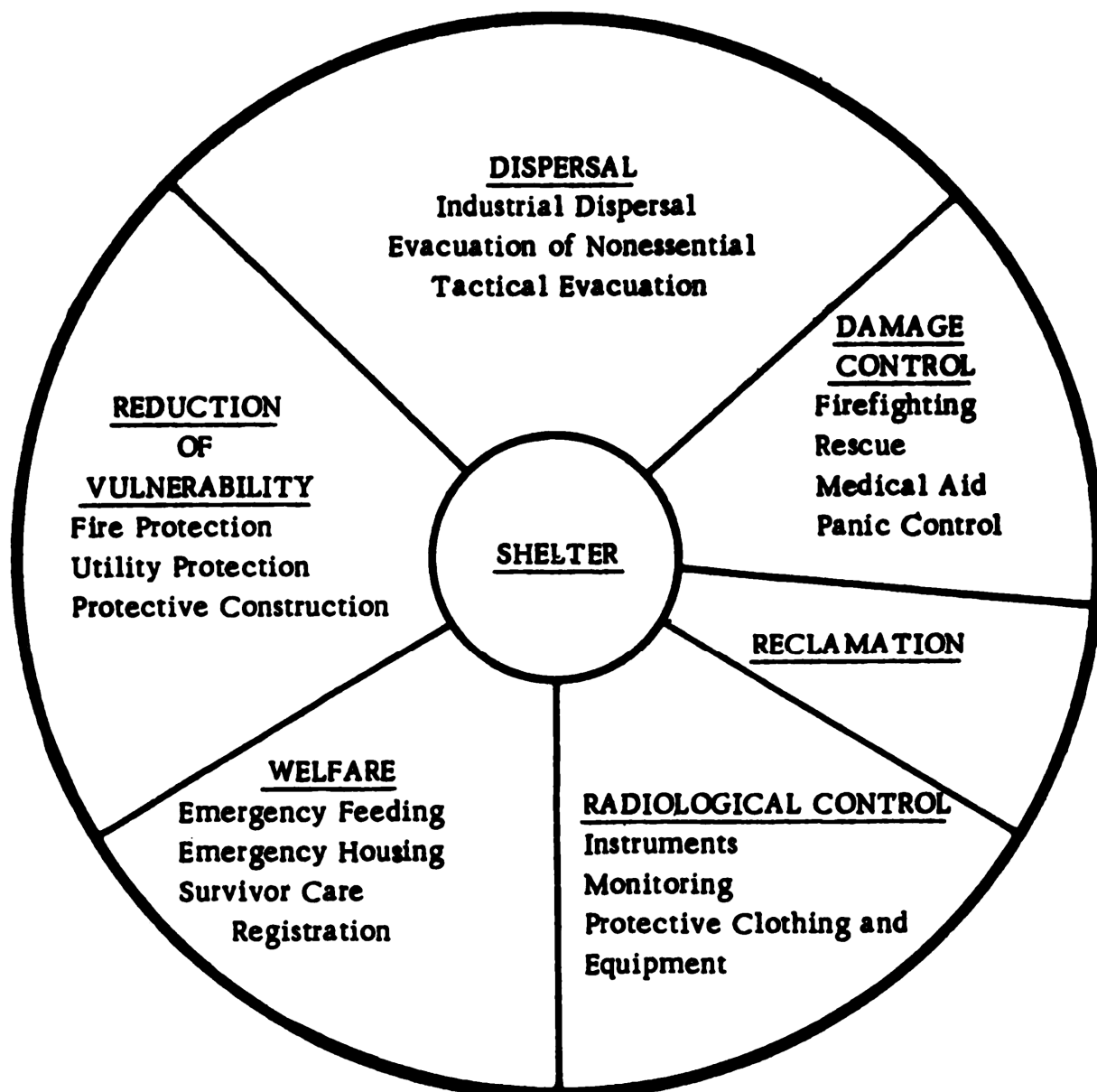
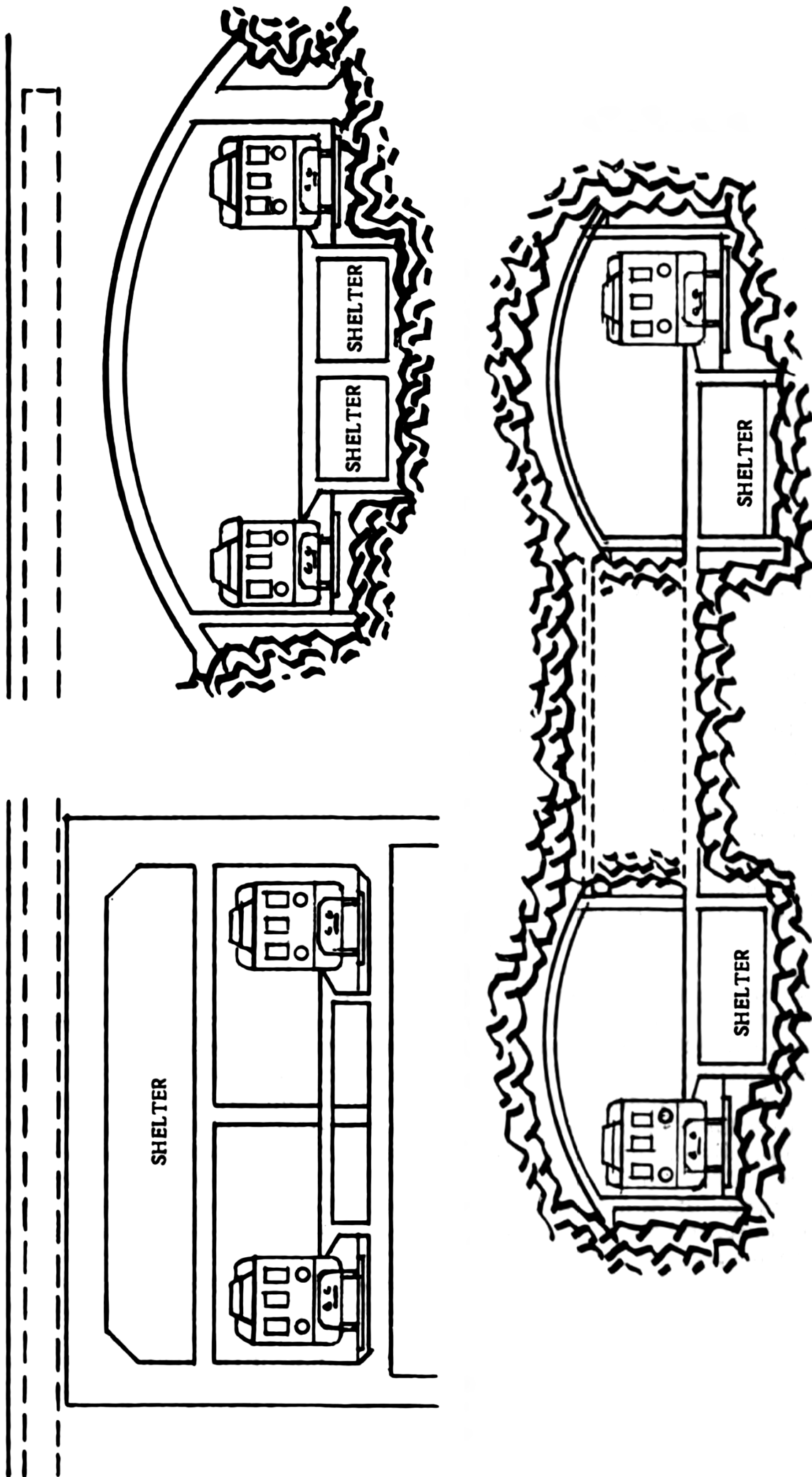


Fig. 1 Countermeasure System in the Emergency Phase

Hon. Val Peterson, Federal Civil Defense Administration Chief, in a speech before the Helicopter Association of America in San Francisco on January 24, 1956, stated: "Today we can give warning of an attack in time for evacuation of the city, but when the guided missile is fully developed then it will be a case of 'take shelter where you can.'"



Three types of shelter. Upper left - over the train platform. Right - below the train platform. Lower - under each platform for trains in opposite directions.

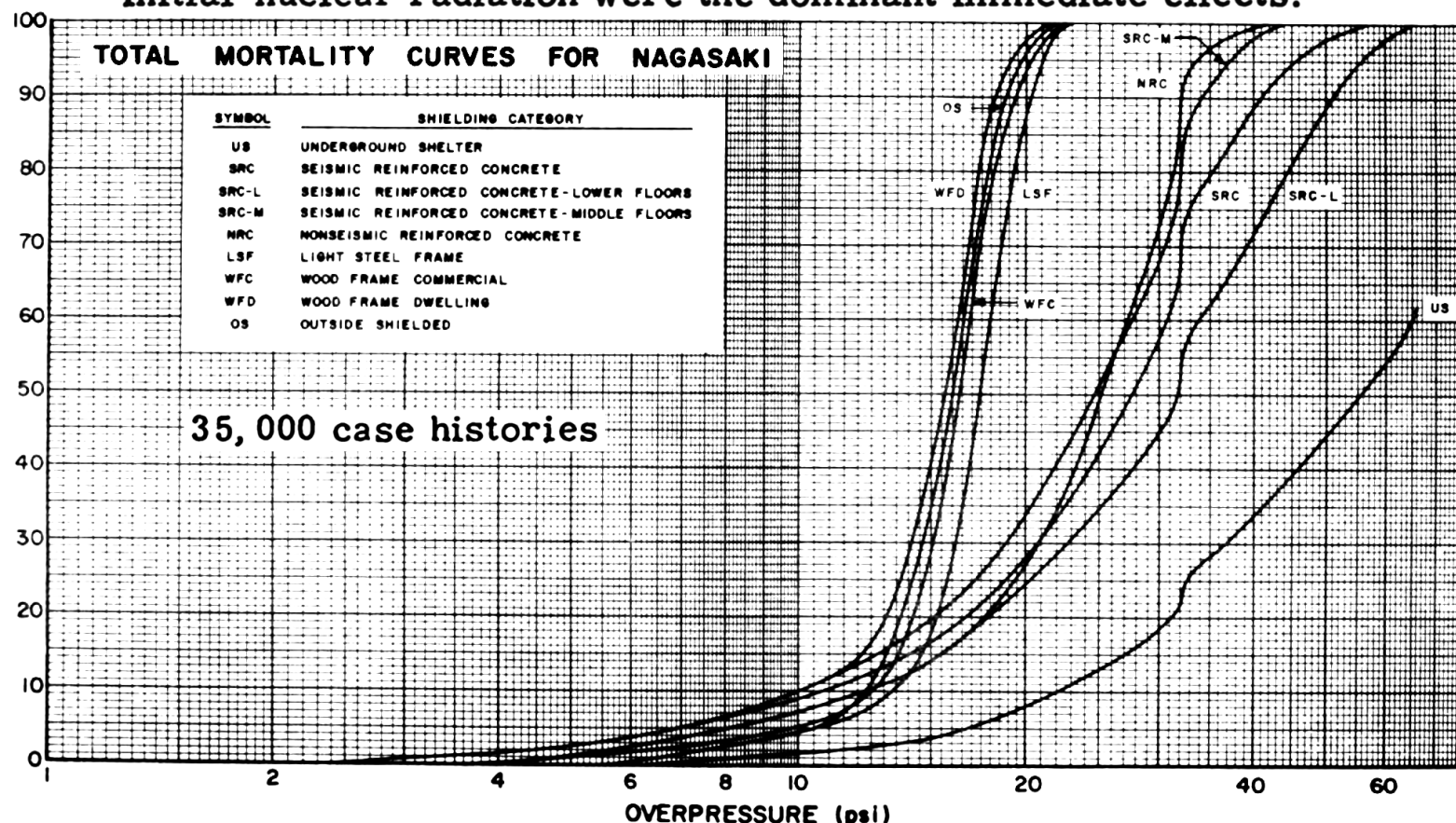
Fig. 2 Shelters in Stockholm Subway (Illustration adapted, courtesy of The American Swedish Monthly)



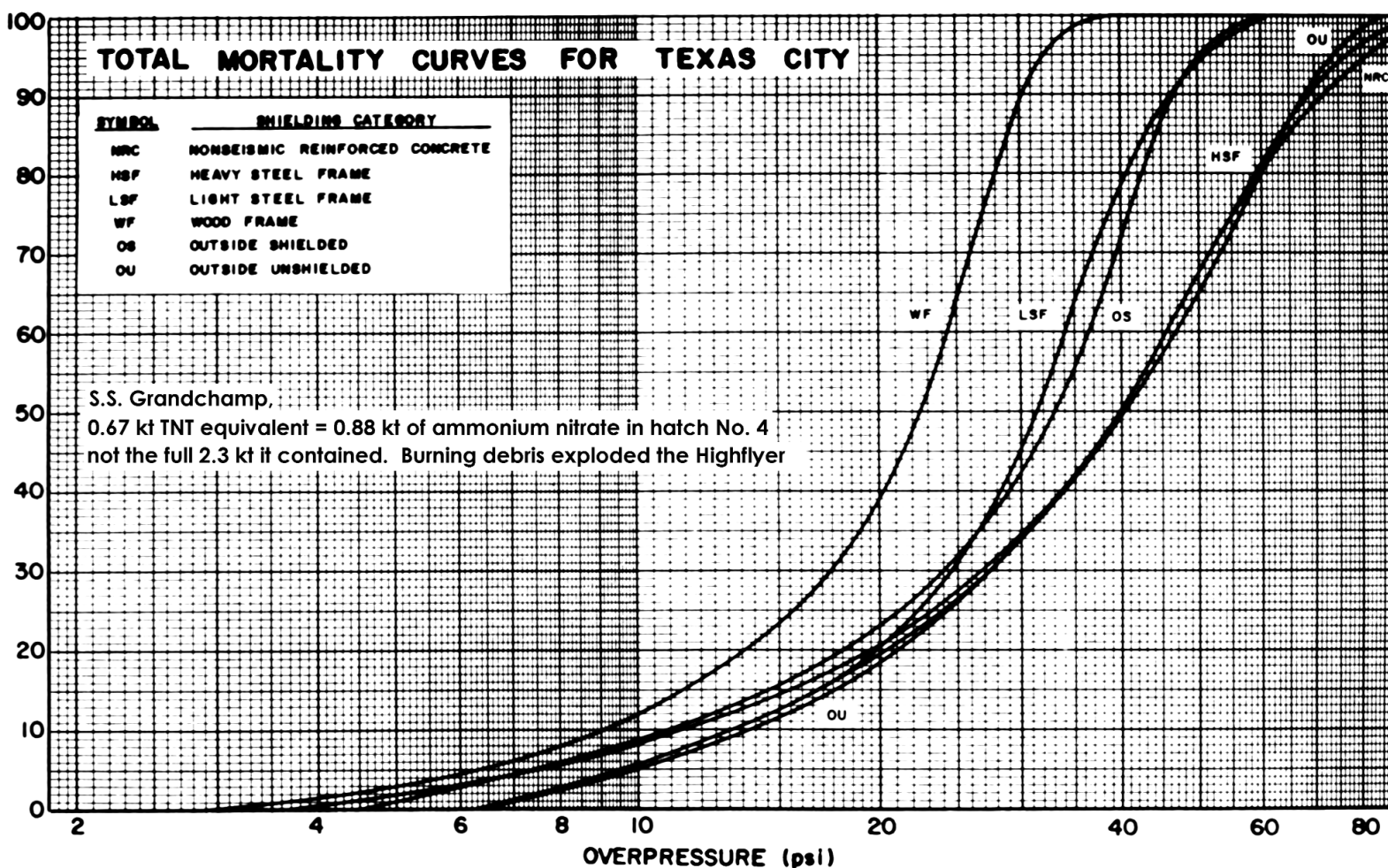
Tunnel shelters in hillside, very close to ground zero in Nagasaki, protected the occupants from blast, thermal radiation, and immediate nuclear radiation.

L. Wayne Davis, Donald L. Summers, William L. Baker, and James A. Keller, Prediction of Urban Casualties and the Medical Load from a High-Yield Nuclear Burst, DC-FR-1060, The Dikewood Corporation

For people in or shielded by structures in Japan, the blast and initial-nuclear radiation were the dominant immediate effects.



S.S. Grandchamp at Texas City exploded in 1947. It contained 2.3 kt of ammonium nitrate in 100-lb paper bags, but only the 0.88 kt in No. 4 hatch was tamped and exploded after catching fire. TNT equivalent was 0.67 kt.



1979 U.S. Office of Technology Assessment, "The Effects of Nuclear War" deceptions

Table 14.—Long-Term Radiation Effects From Nuclear Attacks

Estimated worldwide^b effects from 1-Mt air burst over a city (OTA Case 1):

Somatic effects	
Cancer deaths	200 - 2,000
Thyroid cancers	about 700
Thyroid nodules	about 1,000
Genetic effects	
Abortions due to chromosomal damage	100 - 1,000
Other genetic effects	350 - 3,500

^b Most worldwide fallout would be in the Northern Hemisphere

Above: false LNT radiation scaremongering

Figure 1.—Vulnerability of Population in Various Overpressure Zones

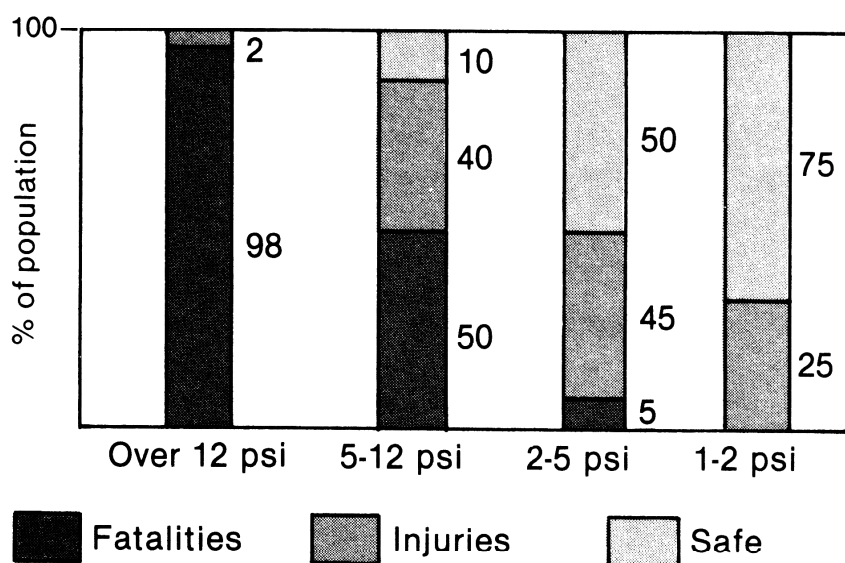


Table 4.—Casualty Estimates (in thousands) (1 Mt on Detroit)

Blast exaggeration:

Region (mi)	Area (mi ²)	Population	Fatalities	Injuries	Uninjured
0-1.7	9.1	70	70	0	0
1.7-2.7	13.8	250	130	100	20
2.7-4.7	46.5	400	20	180	200
4.7-7.4	102.6	600	0	150	450



Damage to unreinforced brick house (5-psi overpressure)

Above: false house collapse (Apple-2 test house after manually demolished!) photo. In fact, outer walls exploded but 1st floor did not collapse at 5 psi, and outward debris motion reduced hazard!

Exaggerated blast effects table ignores modern city concrete buildings which resist blast collapse

Table 5.—Burn Casualty Estimates (1 Mt on Detroit)

Distance from blast (mi)	Survivors of blast effects	Fatalities (eventual)		Injuries	
		2-mile visibility	10-mile visibility	2-mile visibility	10-mile visibility
(1 percent of population exposed to line of sight from fireball)					
0-1.7	0	0	0	0	0
1.7-2.7	120,000	1,200	1,200	0	0
2.7-4.7	380,000	0	3,800	500	0
4.7-7.4	600,000	0	2,600	0	3,000
Total (rounded) . .		1,000	8,000	500	3,000
(25 percent of population exposed to line of sight from fireball)					
0-1.7	0	0	0	0	0
1.7-2.7	120,000	30,000	30,000	0	0
2.7-4.7	380,000	0	95,000	11,000	0
4.7-7.4	600,000	0	66,000	0	75,000
Total (rounded) . .		30,000	190,000	11,000	75,000

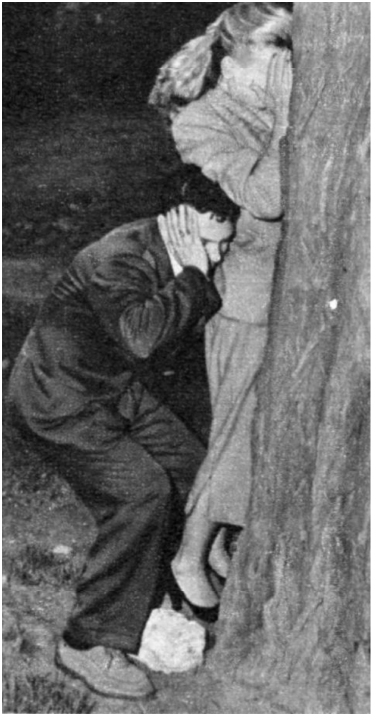
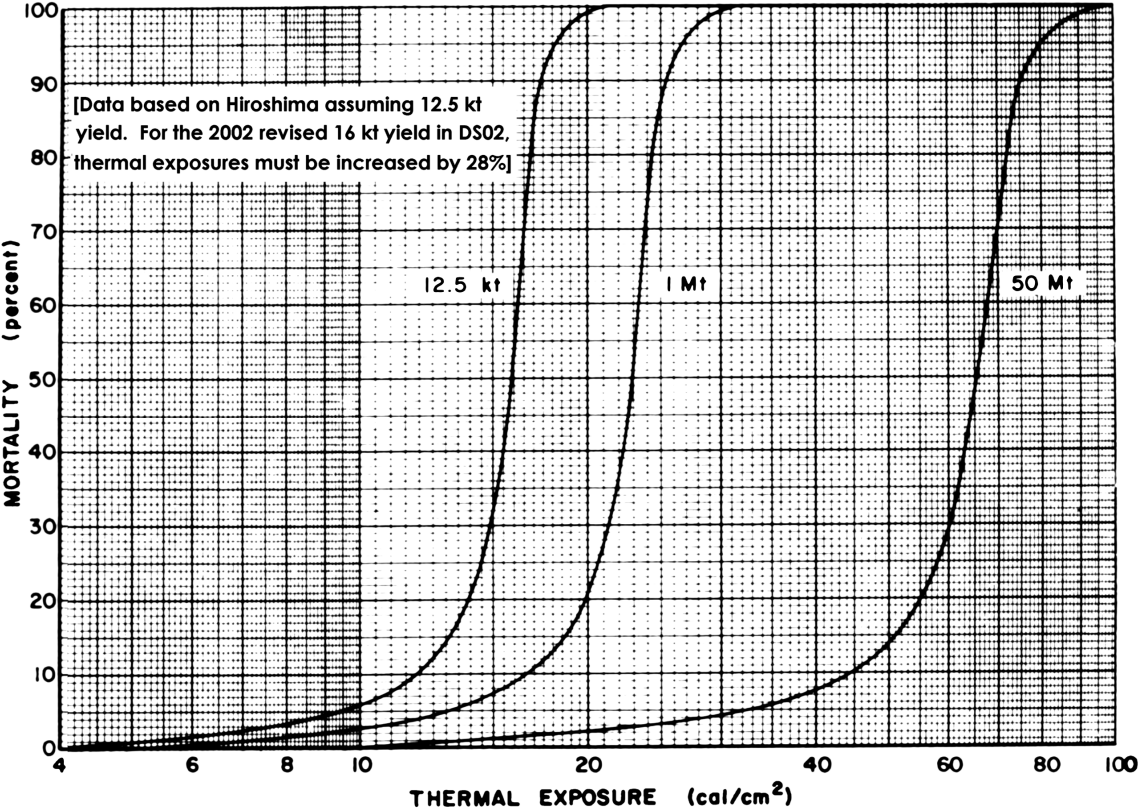
These calculations arbitrarily assume that exposure to more than 6.7 cal/cm² produces eventual death, and exposure to more than 3.4 cal/cm² produces a significant injury, requiring specialized medical treatment.

Exaggerated thermal burns table "arbitrarily" assumes 6.7 cal/cm² is lethal and 3.4 cal/cm² hospitalizes.

This was not true even for light clothing in Hiroshima and for bigger yields even more heat is needed!

Skyline shadowing protects over 90%.

**PROMPT-THERMAL MORTALITY CURVES FROM SURFACE BURSTS
FOR OUTSIDE-UNSHIELDED PERSONS**



Unless you are nude outdoors, 6.7 cal/cm² is not lethal, contrary to the OTA report!

Shirt protection: Nagasaki

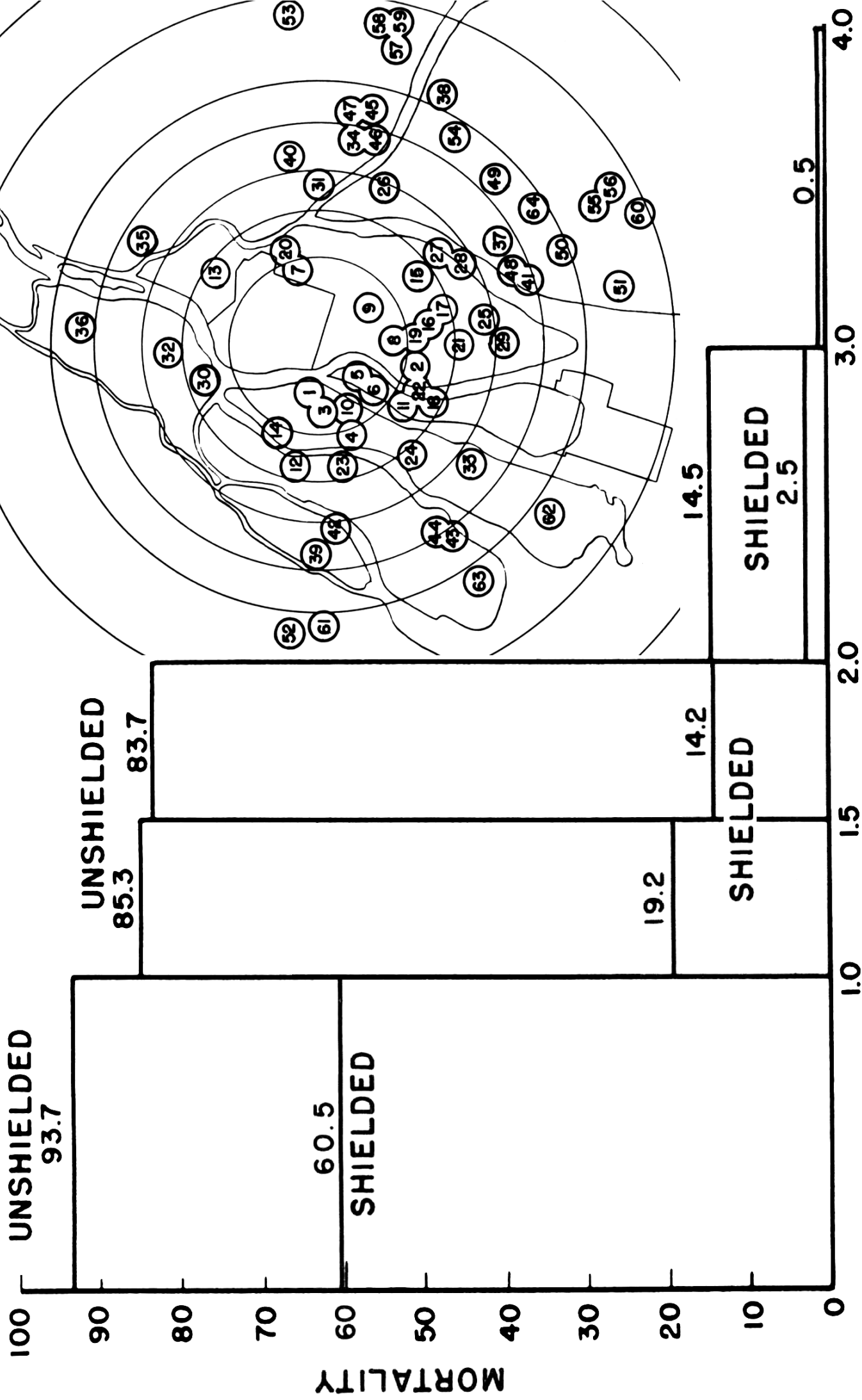
Uniform protection: Hiroshima, "lethal" 6.7 cal/cm² !!!



PROTECTION AGAINST RADIANT HEAT. This patient (photographed by Japanese 2 October 1945) was about 6,500 feet from ground zero when the rays struck him from the left. His cap was sufficient to protect the top of his head against flash burns.

Above: Hiroshima soldier only burned on unclothed skin (1946 USSBS report on Hiroshima and Nagasaki, page 16)

Percent



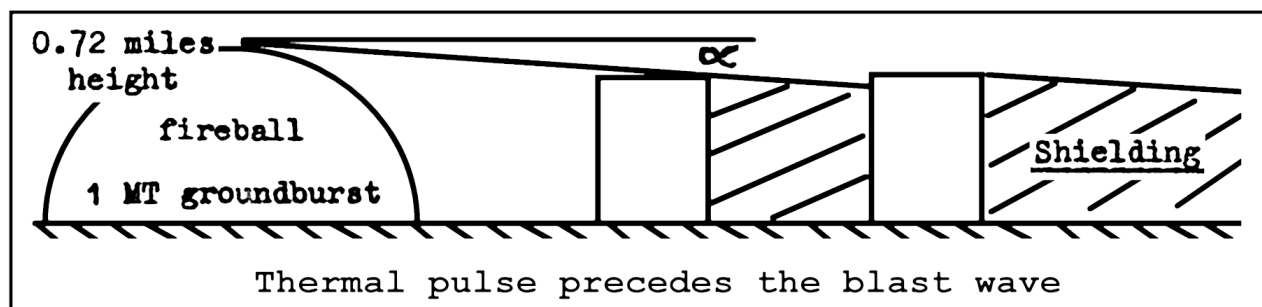
DISTANCE (Kilometers)

SCIENTIFIC ADVISER'S BRANCH

(Paper at Tripartite Thermal Effects Symposium, Dorking, October 1964)

IGNITION AND FIRE SPREAD IN URBAN AREAS
FOLLOWING A NUCLEAR ATTACK

G. R. Stanbury

INITIAL FIRE INCIDENCE

Assuming that buildings on opposite sides of a street which is receiving heat radiation from a direction perpendicular to its length are of the same height we take the average depth of a floor to be 10 ft.

Effect of Shielding: Estimation of the number of exposed floors

Distance from explosion miles	Angle of arrival α°	Width of street (units of 10 ft.)						
		2	3	4	5	6	7	8
3	$13\frac{1}{2}$	.5	.5	1	1	1.5	1.5	2
4	10	.5	.5	.5	1	1	1.5	1.5
5	8	.5	.5	.5	.5	1	1	1

SPREAD OF FIRE

From last war experience of mass fire raids in Germany it was concluded that the overall spread factor was about 2; i.e. about twice as many buildings were destroyed by fire as were actually set alight by incendiary bombs

Number of fires started per square mile in the
fire-storm raid on Hamburg, 27th/28th July, 1943

102 tons H.B.	48 tons, 4 lb. magnesium	40 tons, 30 lb. gel.
100 fires	27,000 bombs	3,000 bombs
	8,000 on buildings	900 on buildings
	1,600 fires	800 fires
2,500 fires in 6,000 buildings		

However, the important thing to note is that the total number of fires started in each square mile (2,500) was nearly half that of the total number of buildings; in other words, almost every other building was set on fire

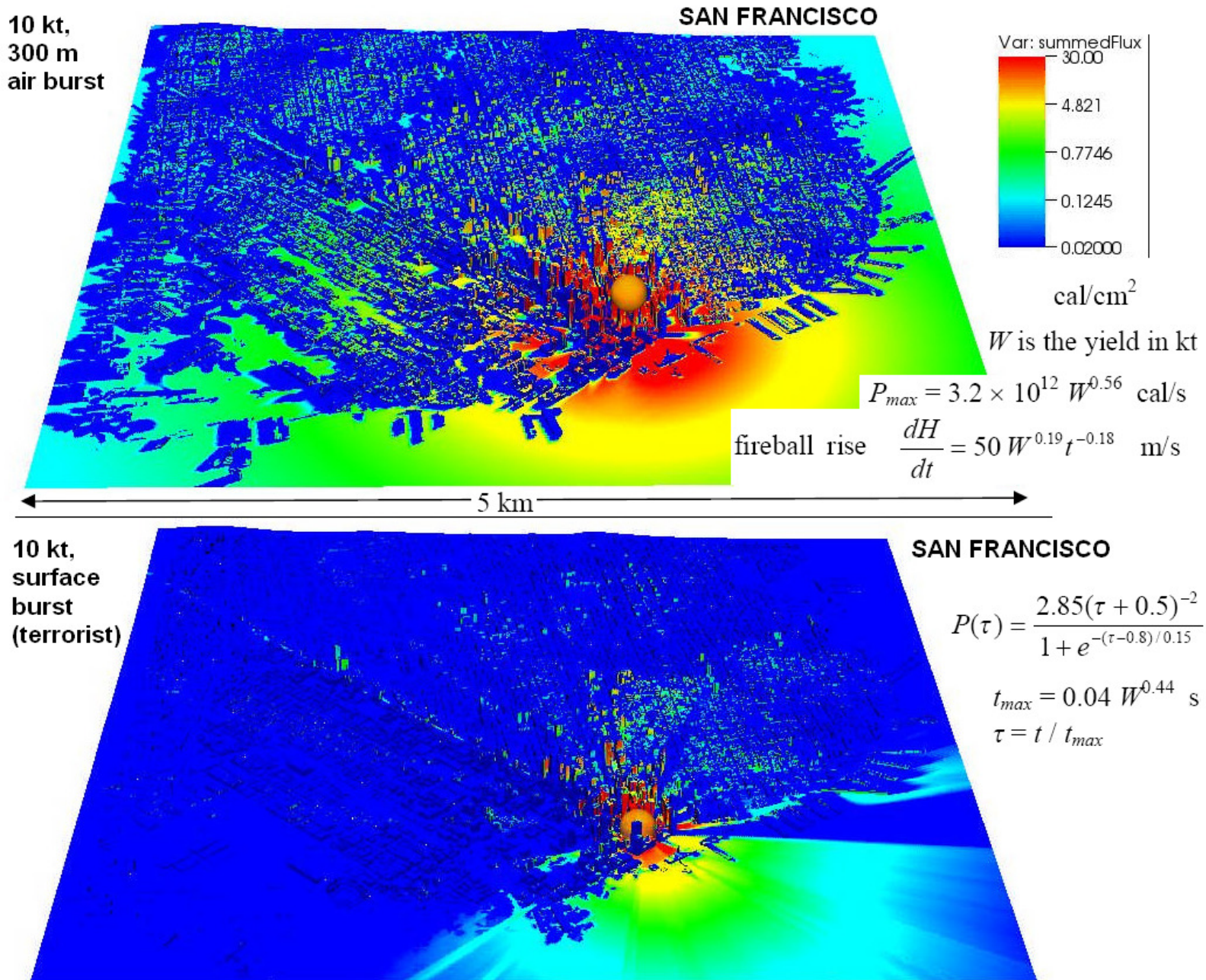
When the figure of 1 in 2 for the German fire storms is compared with the figures for initial fire incidence of ~ 1 in 15 to 30 obtained in the Birmingham and Liverpool studies it can only be concluded that a nuclear explosion could not possibly produce a fire storm.

Thermal Radiation from Nuclear Detonations in Urban Environments

R. E. Marrs, W. C. Moss, and B. Whitlock
Lawrence Livermore National Laboratory

UCRL-TR-231593

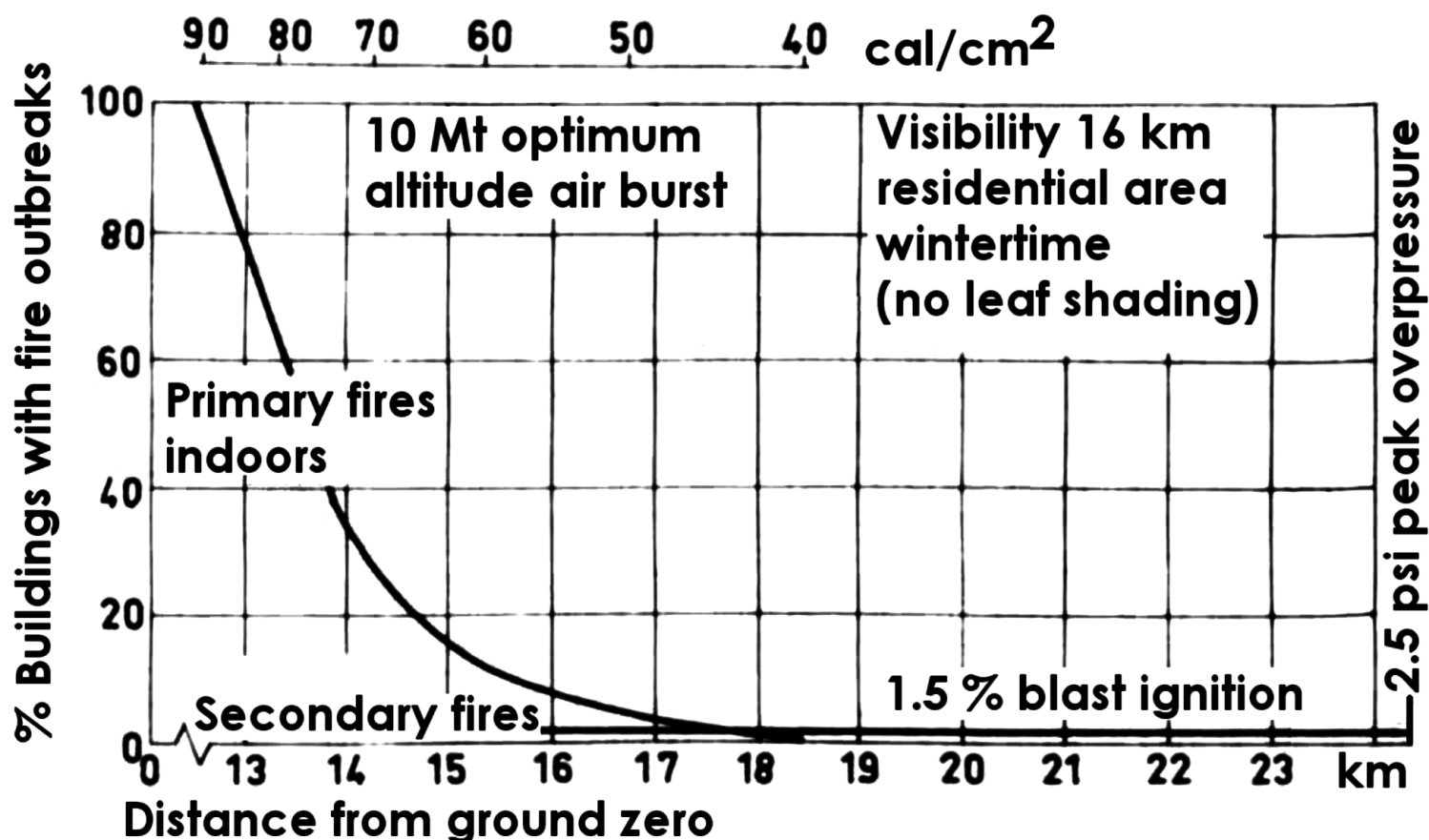
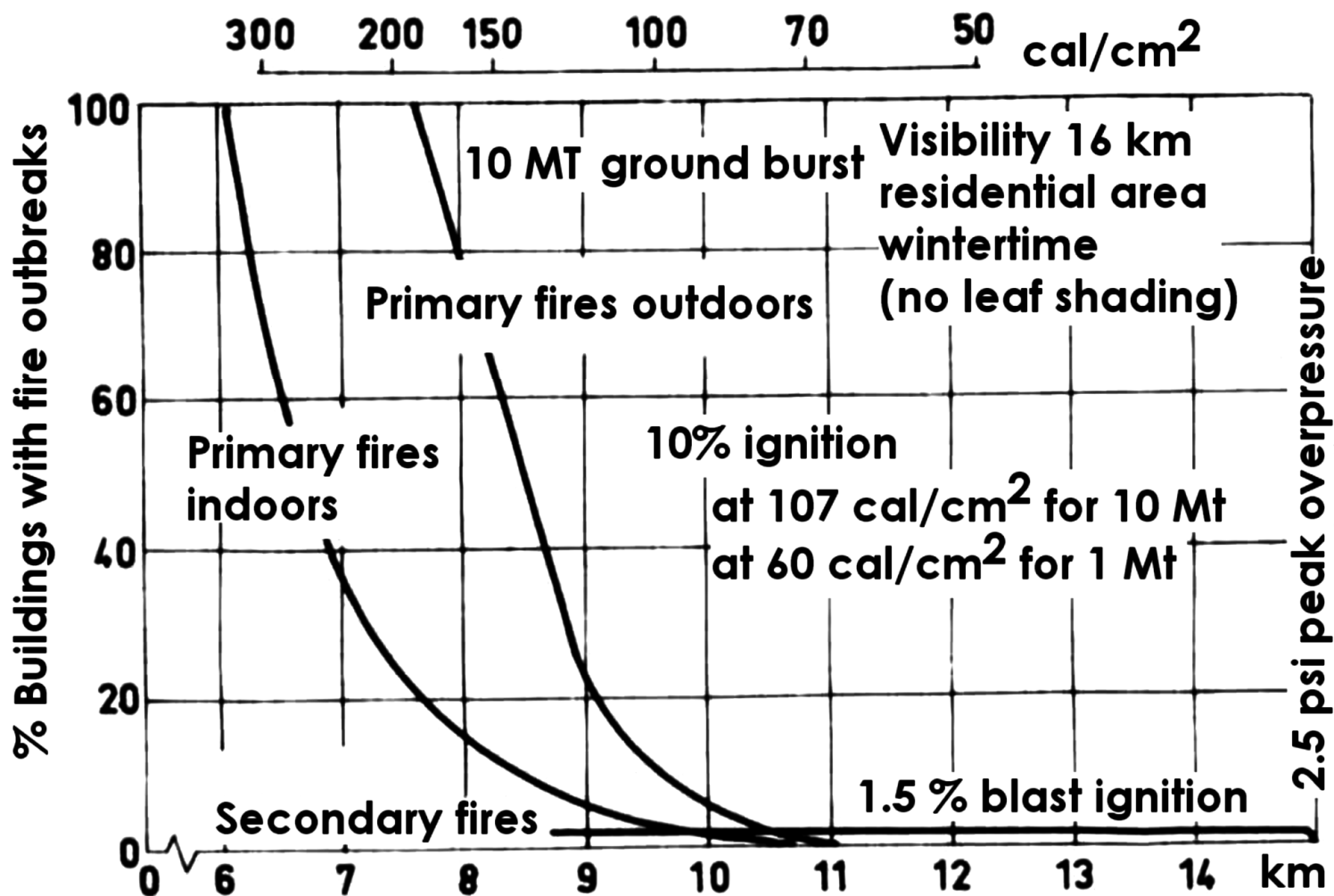
June 7, 2007

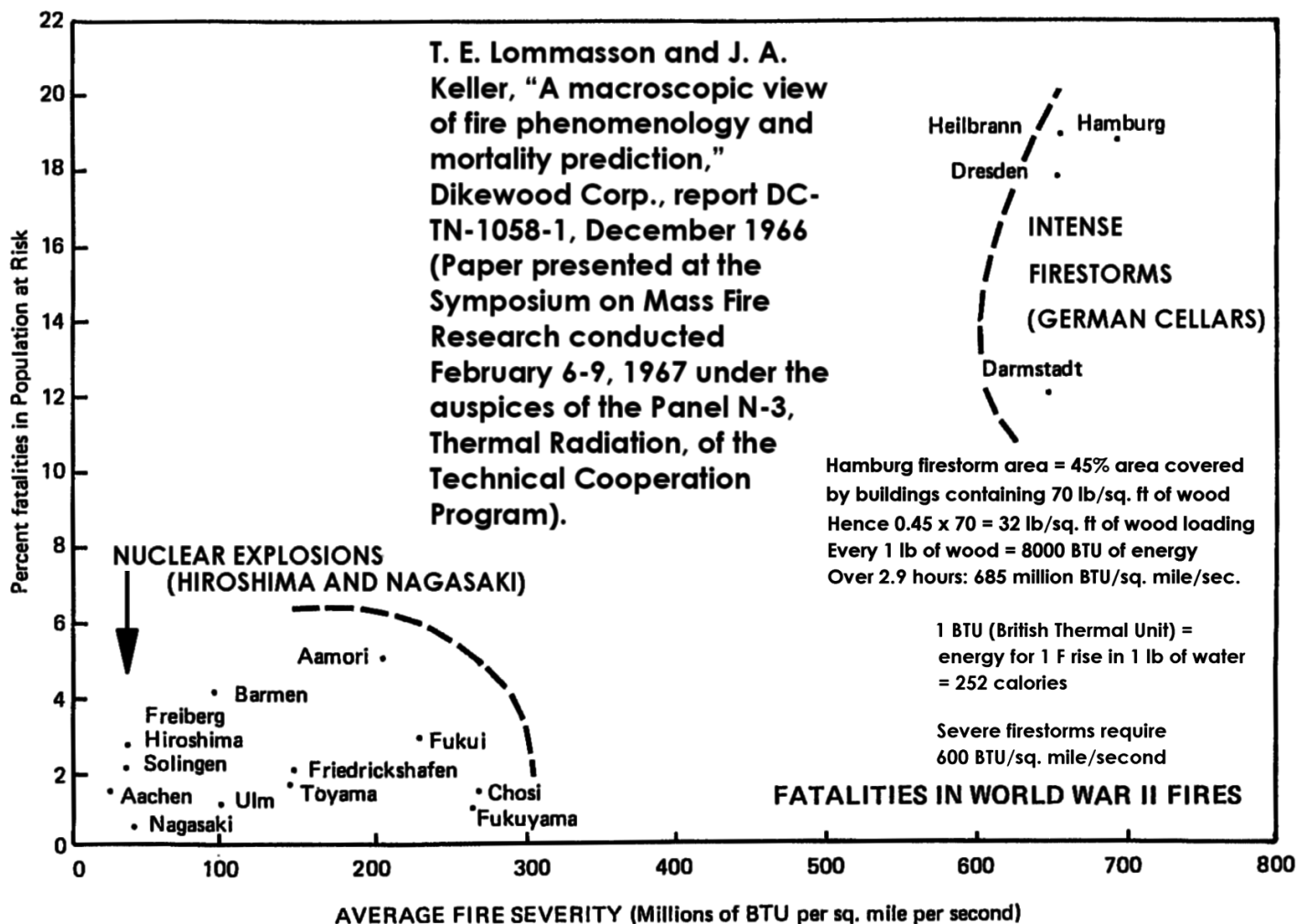
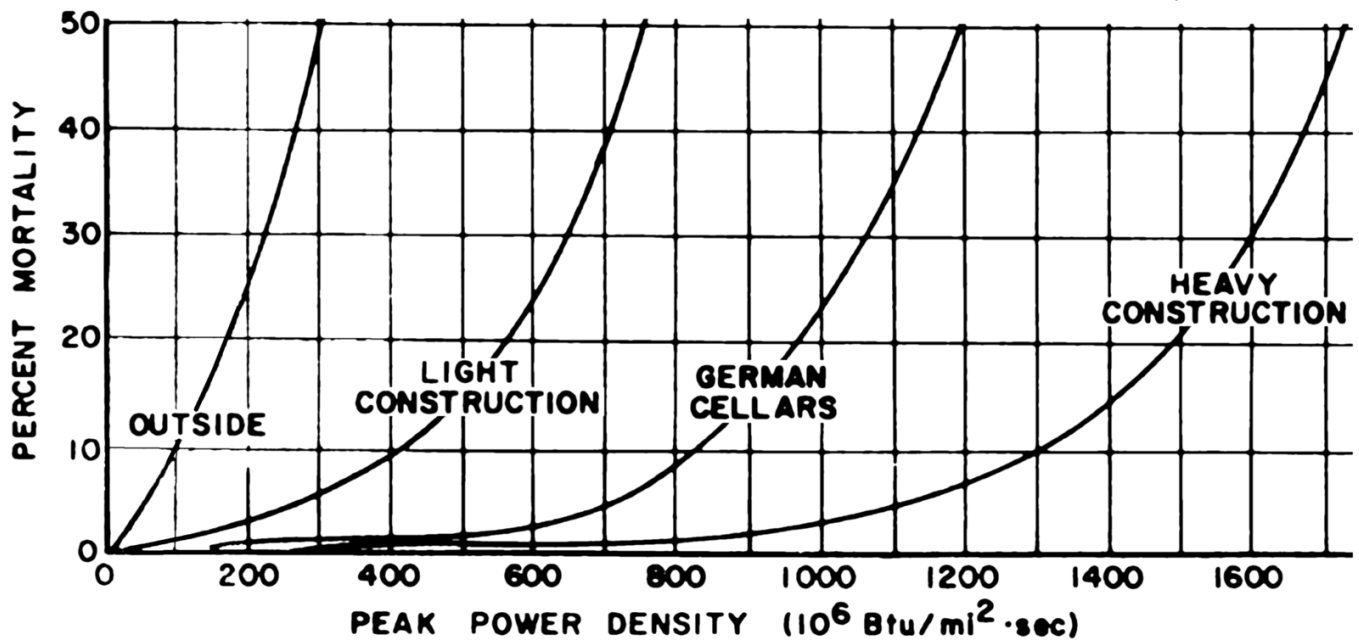


Even without shadowing, the location of most of the urban population within buildings causes a substantial reduction in casualties compared to the unshielded estimates. Other investigators have estimated that the reduction in burn injuries may be greater than 90% due to shadowing and the indoor location of most of the population [6].

We have shown that common estimates of weapon effects that calculate a “radius” for thermal radiation are clearly misleading for surface bursts in urban environments. In many cases only a few unshadowed vertical surfaces, a small fraction of the area within a thermal damage radius, receive the expected heat flux.

John L. Crain, et al., Supplemental Analysis - Civil Defense
Rescue, Stanford Research Institute, AD0625802, 1965.

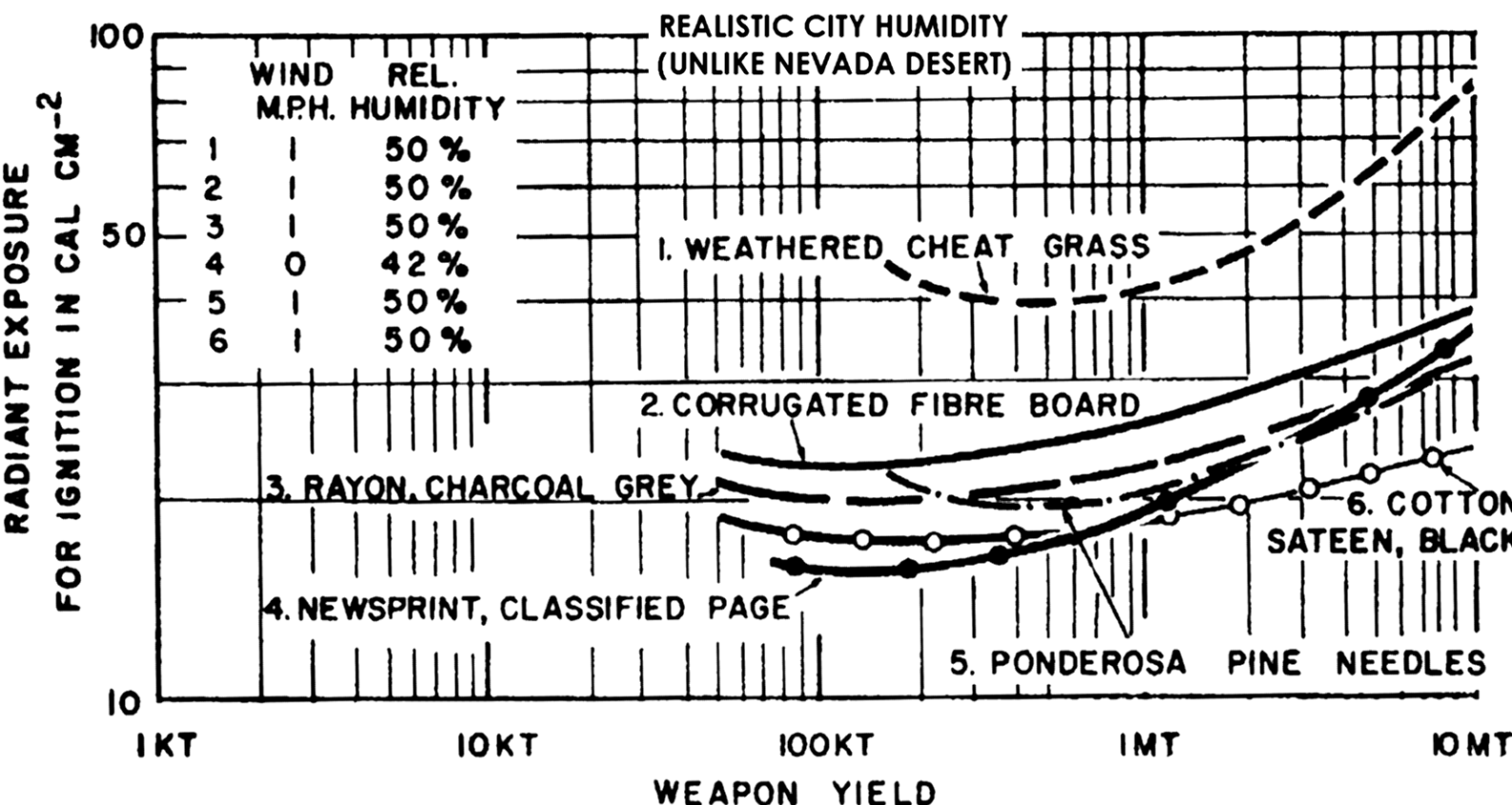




Lommasson and Keller, *A Macroscopic View of Fire Phenomenology and Mortality Predictions*, Dikewood Corporation, DC-TN-1058-1, December 1966.

J. A. Keller, *A Study of World War II German Fire Fatalities*, DC-TN-1050-3, The Dikewood Corporation; April, 1966.

R. Schubert, *Examination of Building Density and Fire Loading in the Districts Eimsbuettel and Hammerbrook of the City of Hamburg in the Year 1943* (20 volumes, in German), Stanford Research Institute; January, 1966.



"TECHNICAL OBJECTIVE AW-7, CRITICAL RADIANT EXPOSURES FOR PERSISTENT IGNITION", JULY 1960, J. BRACCIAVENTI & F. DEBOLD AD-249476; DASA-1194

UCRL-TR-231593



Thermal radiation from nuclear detonations in

urban environments

June 7, 2007

Even without shadowing, the location of most of the urban population within buildings causes a substantial reduction in casualties compared to the unshielded estimates. Other investigators have estimated that the reduction in burn injuries may be greater than 90% due to shadowing and the indoor location of most of the population [6].

We have shown that common estimates of weapon effects that calculate a "radius" for thermal radiation are clearly misleading for surface bursts in urban environments. In many cases only a few unshadowed vertical surfaces, a small fraction of the area within a thermal damage radius, receive the expected heat flux.

Thermal radiation shadowing in modern high-rise cities

TENEMENTS, COMMERCIAL,



~~CONFIDENTIAL~~

WT-770

UNCLASSIFIED

This document consists of 64 pages
No. 196 of 295 copies, Series A

AD B951673

OPERATION UPSHOT-KNOTHOLE

Project 8.5

THERMAL RADIATION PROTECTION AFFORDED TEST ANIMALS BY FABRIC ASSEMBLIES

REPORT TO THE TEST DIRECTOR

by

J. Fred Oesterling and Staff

UNCLASSIFIED

REGRADED

BY AUTHORITY OF DA Form 1575-FCR 274/24
BY B. W. Dale 23 SEP 64 July 1955

~~FORMERLY RESTRICTED DATA~~
Handle As Restricted Data In Foreign
Dissemination Section 144B, Atomic
Energy Act, 1954

~~RESTRICTED DATA~~

This document contains restricted data as
defined in the Atomic Energy Act of 1954.
Its transmittal or the disclosure of its
contents in any manner to an unauthorized
person is prohibited.

Quartermaster Research and Development Laboratories
Army Medical Service Graduate School
Walter Reed Army Medical Center
University of Rochester Atomic Energy Project

~~CONFIDENTIAL~~ UNCLASSIFIED

4.1.2 Factors Contributing to the Greater Degree of Thermal Protection in the Field.

There are several conditions encountered in the field, especially at the higher energy levels, but not duplicated in the laboratory (at least not up to the present time) that may account for the fact that like amounts of thermal energy did not produce comparable results in the laboratory and in the field. First, the thermal energy is delivered much more rapidly with the explosion of an atomic bomb than it is in the laboratory. Second, due to smoke obscuration the animals in the field actually received a smaller percentage of the total energy delivered than they did in the laboratory. Third, the blast wave following the explosion tended to extinguish flames and remove char, whereas no such wave was present in the laboratory tests. Fourth, where the heat reached the fabric layer next to the skin, uniform drape (or spacing) provided additional protection in the field.

(2) Motion pictures of clothed animals, exposed to 50.0 and 33.5 cal/cm² on Shots 9 and 10 respectively, showed heavy clouds

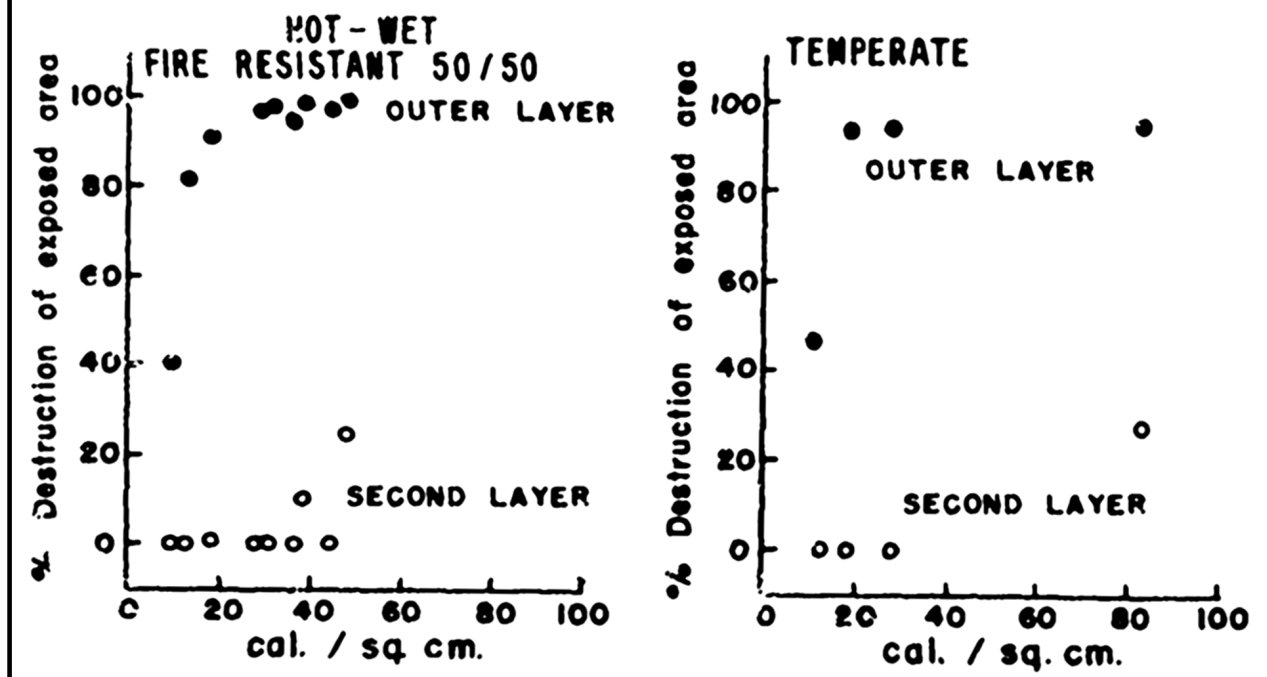
45

of black smoke enveloping the animals within 120 ms of the explosion.

(3) The blast wave following the explosion, which has not been duplicated in laboratory applications of thermal energy, has two possible protective effects. First, it can be expected to extinguish flames induced by the radiation in assemblies not treated for fire resistance, thus removing a source of high heat. Although the blast wave may not actually extinguish the flame in all cases,* it can be expected in general to have this effect. Second, the blast wave would tend to remove any char which, if allowed to remain, would act as a heat reservoir and increase the likelihood of a severe burn.

46

Fig. 3.5 Destruction of Outer and Second Layers of Pigs' Uniforms (Shots 9 and 10)



CONFIDENTIAL

WT- 774

Copy No. 126 A

Operation **UPSHOT-KNOTHOLE**

NEVADA PROVING GROUNDS

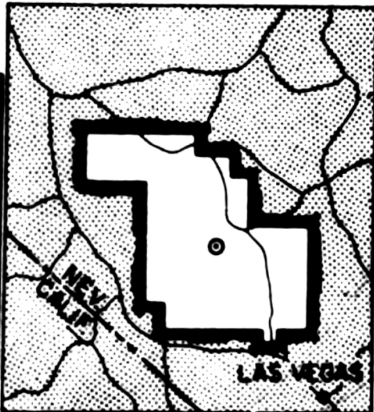
March - June 1953

Project 8.11a

INCENDIARY EFFECTS ON BUILDING
AND INTERIOR KINDLING FUELS

(ENCORE EFFECT REPORT)

27 kt at 2,423 feet altitude, 19% humidity
(DASA-1251) (Note: cities humidity is ~50-80%)



RESTRICTED DATA

This document contains restricted data as defined in the Atomic Energy Act of 1946. Its transmittal or the disclosure of its contents in any manner to an unauthorized person is prohibited.

HEADQUARTERS FIELD COMMAND, ARMED FORCES SPECIAL WEAPONS PROJECT
SANDIA BASE, ALBUQUERQUE, NEW MEXICO

CONFIDENTIAL

Weapon test report WT-774, Project 8.11a, Incendiary effects on buildings and interior kindling fuels



ENCORE test, Nevada, 1953
10' x 12' wooden houses with 4' x 6' windows
17 calories/sq. cm thermal flash



Immediate room flashover during thermal pulse ("Encore effect") in inflammables-filled house while fire-resistant fabrics in other house survived!



LEFT HOUSE: fire-resistant furnishings
(woolen rugs and clothes, vinyl plastic draperies)



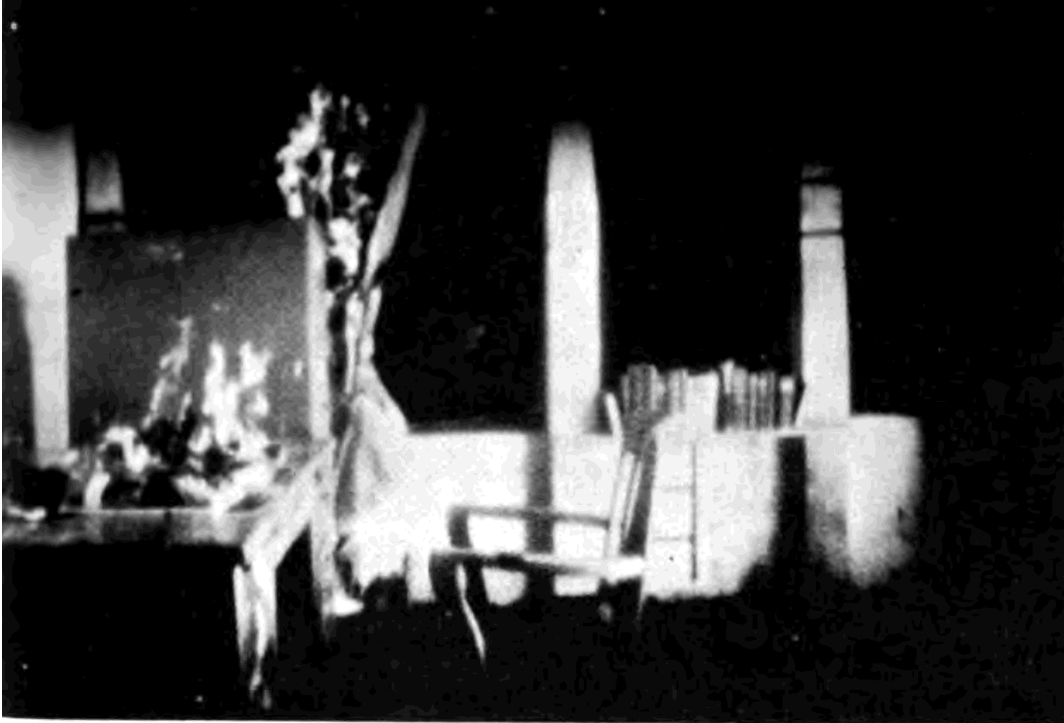
RIGHT HOUSE: non-fire resistant furnishings
plus inflammable magazines and newspapers



Smouldering armchair extinguished 1 hour after detonation, when recovery party arrived at house

EFFECTS OF 1 PSI OVERPRESSURE ON IGNITIONS

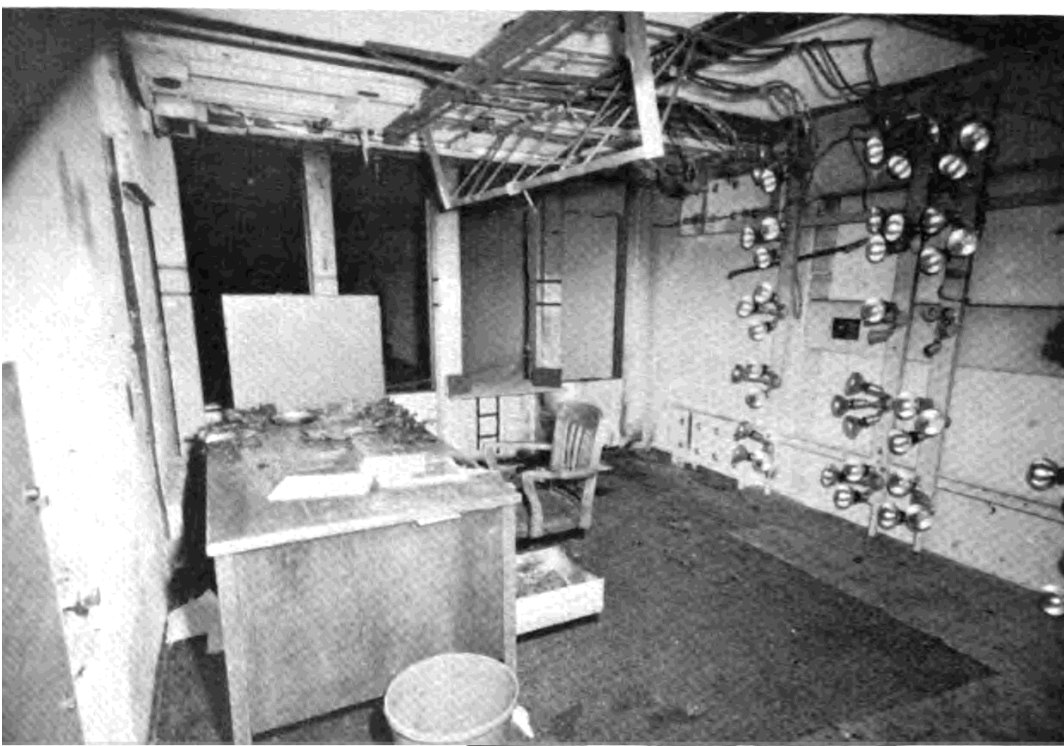
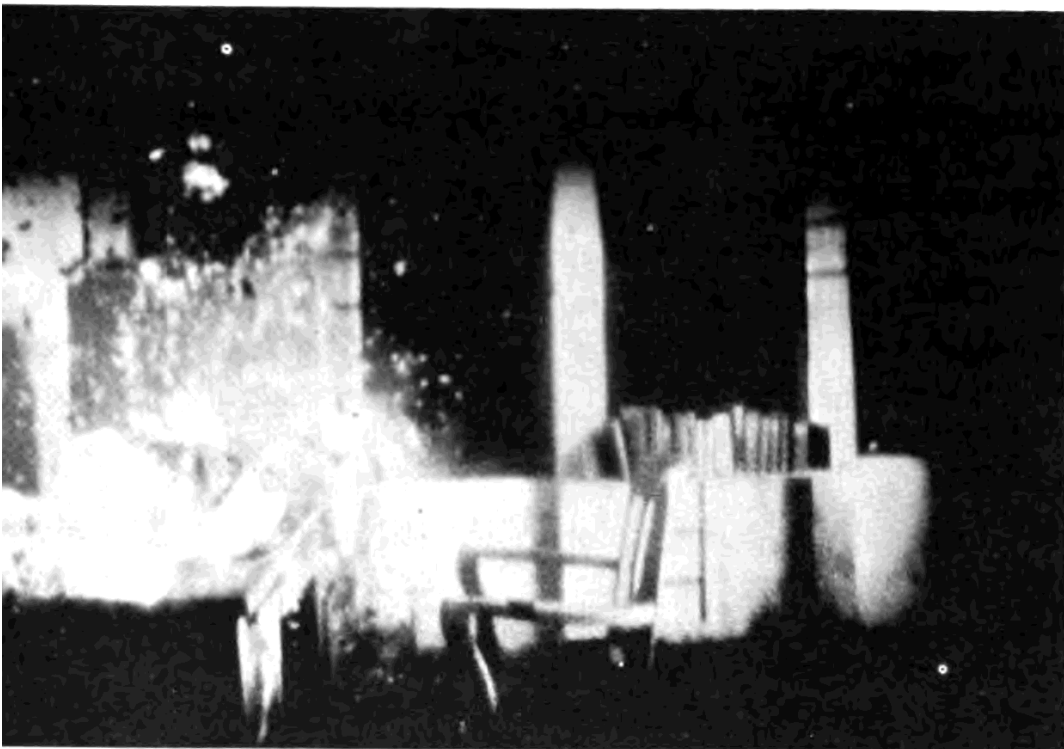
From: Goodale, Effects of
Air Blast on Urban Fires
URS 7009-14 Dec. 1970
(AD 723 429)



**Blast winds both
cool burning
material and
upset flame
convection system.**

**50% of burning
curtains are
extinguished by
1 psi overpressure**

**100% are put out by
2.5 psi. Note that
burning LIQUIDS
in high-wall trays
are not put out by
blast waves, but this
is not relevant to
city fires.**



**Burning beds can
continue to smoulder
until extinguished
with water.**

1	2	cms	The National Archives	ins	1	2
Ref.:		HO 225/116		C-50594		

3rd October, 1963.

~~RESTRICTED~~

*J.A.
9/89*

For Pa

HOME OFFICE

HO 225/116

SCIENTIFIC ADVISER'S BRANCH

CD/SA 116

RESEARCH ON BLAST EFFECTS IN TUNNELS

With Special Reference to the Use of London Tubes as Shelter

by F. H. Pavry

Summary and Conclusions

The use of the London tube railways as shelter from nuclear weapons raises many problems, and considerable discussion of some aspects has taken place from time to time. But - until the results of the research here described were available - no one was able to say with any certainty whether the tubes would provide relatively safe shelter or not.

The more recent research here described showed for the first time that a person sheltering in a tube would be exposed to a blast pressure only about $\frac{1}{3}$ as great as he would be exposed to if he was above ground. (In addition, of course, he would be fully protected from fallout in the tube.)

Large-Scale Field Test ($\frac{1}{40}$) at Suffield, Alberta

The test is fully described in an A.W.R.E. report⁽⁶⁾. The decision of the Canadian Defence Research Board to explode very large amounts of high explosive provided a medium for a variety of target-response trials that was welcome at a time when nuclear tests in Australia were suspended. A.W.R.E. used the 100-ton explosion in 1961 to test, among other items, the model length of the London tube, at $\frac{1}{40}$ th scale, that had already been tested at $\frac{1}{117}$ scale.

Blast Entry from Stations

There was remarkable agreement with the $\frac{1}{117}$ th scale trials: "maximum overpressure in the train tunnels was of the order of $\frac{1}{3}$ rd the corresponding peak shock overpressure in the incident blast. The pressures in the stations were about $\frac{1}{6}$ th those in the corresponding incident blast".

(6) $\frac{1}{40}$ th Scale Experiment to Assess the Effect of Nuclear Blast on the London Underground System. A.W.R.E. Report E2/62.
(Official Use Only.)

100 ton TNT test on 1000 ft section of London Underground tube at Suffield, Alberta, 3 Aug 1961

Atomic Weapons Research Establishment, "1/40th Scale Experiment to Assess the Effect of Nuclear Blast on the London Underground System", Report AWRE-E2/62, 1962, Figure 30. (National Archives ES 3/57.)

200 FT FROM GROUND ZERO	400 FT FROM GROUND ZERO
100 PSI OUTSIDE	20 PSI OUTSIDE
30 PSI IN TUBES	7.2 PSI IN TUBES
15 PSI IN TUBE STATIONS	4.3 PSI IN TUBE STATIONS



Aldwych Underground tube station as Blitz shelter, 8 October 1940

THE EFFECTS OF THE ATOMIC BOMBS AT HIROSHIMA AND NAGASAKI

REPORT OF THE BRITISH MISSION TO JAPAN

40. The provision of air raid shelters throughout Japan was much below European standards. Those along the verges of the wider streets in Hiroshima were comparatively well constructed : they were semi-sunk, about 20 ft. long, had wooden frames, and 1 ft. 6 ins. to 2 ft. of earth cover. One is shown in photograph 17. Exploding so high above them, the bomb damaged none of these shelters.

41. In Nagasaki there were no communal shelters except small caves dug in the hillsides. Here most householders had made their own backyard shelters, usually slit trenches or bolt holes covered with a foot or so of earth carried on rough poles and bamboos. These crude shelters, one of which is shown in photograph 18, nevertheless had considerable mass and flexibility, qualities which are valuable in giving protection from blast. Most of these shelters had their roofs forced in immediately below the explosion ; but the proportion so damaged had fallen to 50 per cent. at 300 yards from the centre of damage, and to zero at about $\frac{1}{2}$ mile.

42. These observations show that the standard British shelters would have performed well against a bomb of the same power exploded at such a height. Anderson shelters, properly erected and covered, would have given protection. Brick or concrete surface shelters with adequate reinforcement would have remained safe from collapse. The Morrison shelter is designed only to protect its occupants from the debris load of a house, and this it would have done. Deep shelters such as the refuge provided by the London Underground would have given complete protection.

LONDON

1946



Photo No. 17. HIROSHIMA. Typical, part below ground, earth-covered, timber framed shelter 300 yds. from the centre of damage, which is to the right. In common with similar but fully sunk shelters, none appeared to have been structurally damaged by the blast. Exposed woodwork was liable to "flashburn." Internal blast probably threw the occupants about, and gamma rays may have caused casualties.



Photo No. 18. NAGASAKI. Typical small earth-covered back yard shelter with crude wooden frame, less than 100 yds. from the centre of damage, which is to the right. There was a large number of such shelters, but whereas nearly all those as close as this one had their roofs forced in, only half were damaged at 300 yds., and practically none at half a mile from the centre of damage.



Aldwych tube London 21 Oct 1940: effective Blitz air raid shelter



THOSE WHO WENT TO SHELTERS began a new kind of night-life. Some took over the Tubes, camping out in this fashion—Elephant and Castle Station, 11th November, 1940.

INDUSTRIAL PREPAREDNESS AND NUCLEAR WAR SURVIVAL

WEDNESDAY, NOVEMBER 17, 1976

U.S. CONGRESS,
JOINT COMMITTEE ON DEFENSE PRODUCTION,
Washington, D.C.

MR. THOMAS K. JONES

Mr. Jones is the Program and Product Evaluation Manager for the Boeing Aerospace Company. In this capacity he directs analyses and studies of national requirements, evaluates the capabilities of present and potential product lines to satisfy national requirements, and determines the allocation of research budgets to product programs.

From June 1971 thru August 1974, Mr. Jones was employed by the Office of the Secretary of Defense (DDR&E) in support of the Strategic Arms Limitations Talks (SALT). In this assignment, he served as Deputy Director, OSD SALT support group and as Senior Adviser to the OSD member of the U.S. SALT delegation. Through his appointment as a consultant to the Defense Science Board, he is continuing to support the SALT activities.

From 1954 until his employment by the Department of Defense, Mr. Jones was employed by Boeing in a number of design engineering, system engineering, and management assignments. These assignments included work on options to extend the viability of the Minuteman ICBM system, study of strategic tanker systems, analysis of ABM systems, system engineering of manned space systems, and design of strategic bomber systems.

STATEMENT OF MR. THOMAS K. JONES, PROGRAM AND PRODUCT EVALUATION MANAGER, BOEING AEROSPACE COMPANY, AC- COMPANIED BY MR. JOHN R. POTTER, DIRECTOR OF FACILITIES, BOEING COMMERCIAL AIRPLANE COMPANY; AND MR. EDWIN N. YORK, NUCLEAR EFFECTS SPECIALIST

Evacuation, because it distributes people over a comparatively large area, allow them to survive. The United States could, by foregoing half the effectiveness of its arsenal against industrial facilities, spread a lethal level of radioactive fallout over 15 percent of the Soviet Union. However, the evacuees will dig simple shelters to protect against this possibility. The decay rate of that radiation intensity would, within a week, permit the Russians to be out of their shelters for at least an 8-hour workday in 97 percent of their territory.

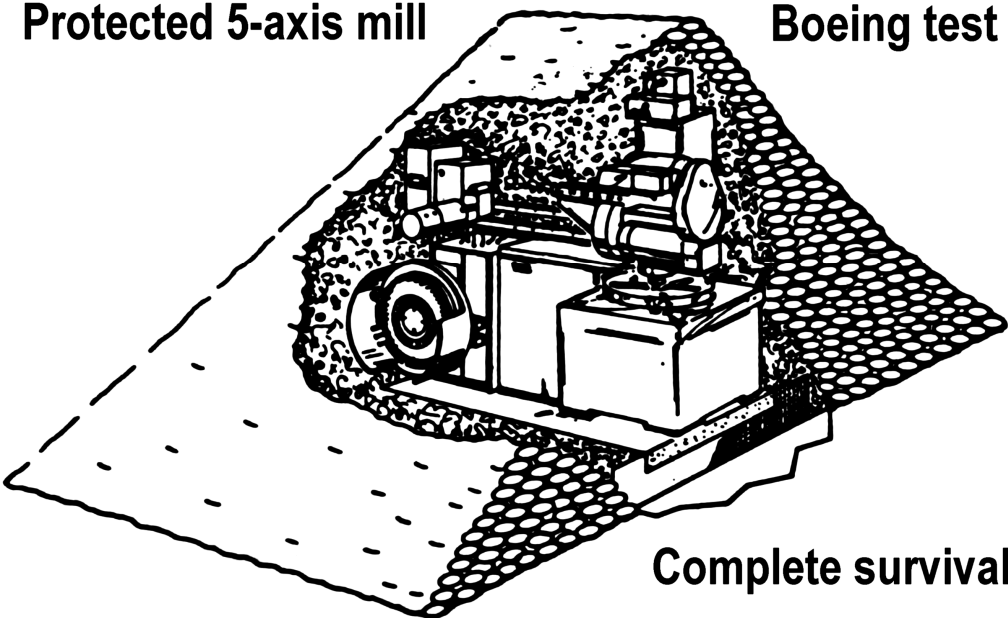
The Soviet civil defense manuals also provide for a number of ways to protect the critical production machinery within the factories. A book written by A. A. Gromov, hero of Socialist labor and director of the First State Ball Bearing Plant, outlines how these protective methods are being applied to his factory.

A gas-powered minibike was successfully protected against a blast pressure of 600 pounds per square inch, and a soil heave of 1½ feet; after the test, it was dug out, started and driven away.

In brief, the results of this test indicate that industrial machines, if properly protected, can survive within a few hundred feet from a 40 kiloton nuclear blast, or 2,000 feet from a 1 megaton.

These protective measures, if applied to the Seattle-Tacoma-Everett metropolitan area, could permit resumption of some production operations as early as 4 to 12 weeks after a nuclear attack, depending on the level of radiation intensity.

Protected 5-axis mill



Boeing test

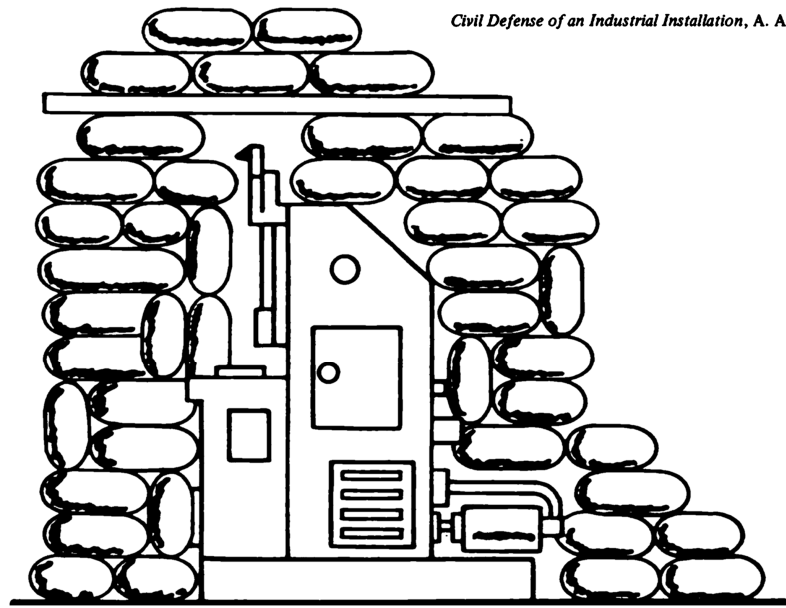


600 psi blast protection
for a minibike at .5 kt TNT
"Dice Throw" 6 Oct 1976

Complete survival

Dirt filled bags protecting USSR machinery from nuclear war

Civil Defense of an Industrial Installation, A. A. Gromov



D180-20236-1

Figure A-3. Comparison of Alternative Indices of Capability

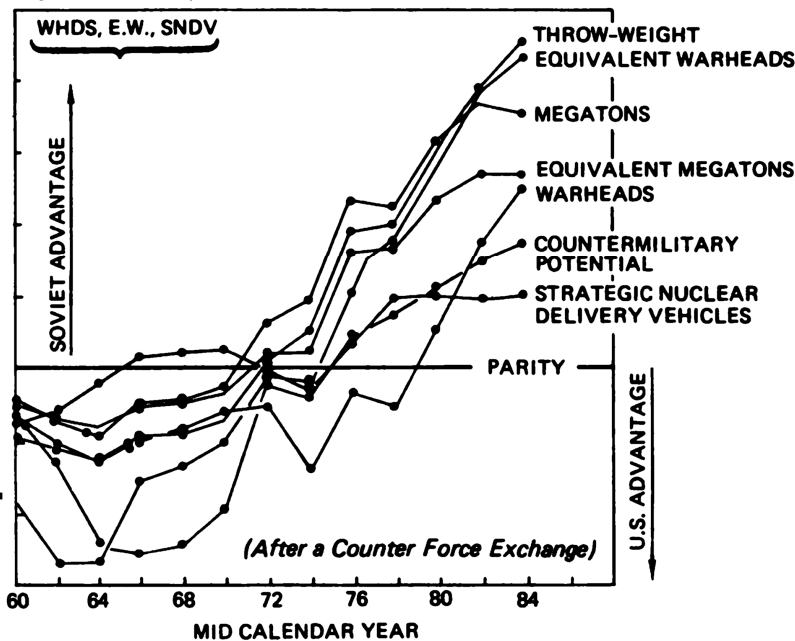
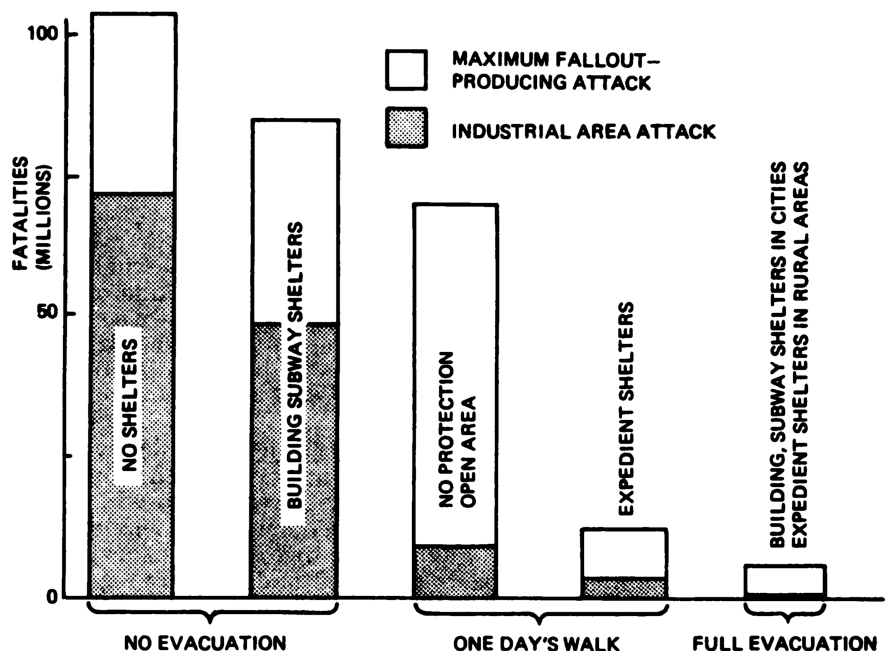
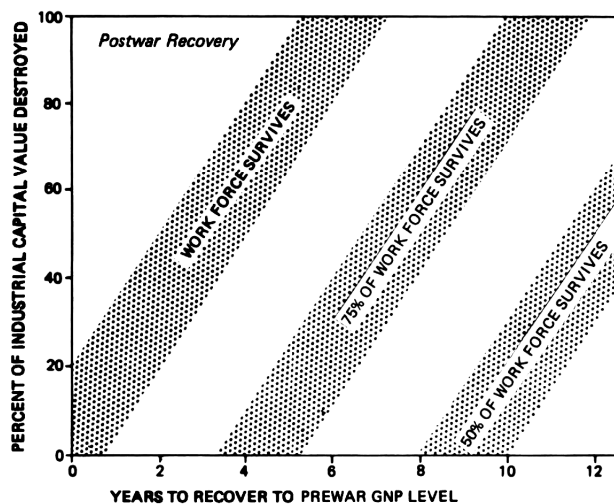


Рис. 2. Вариант консервации

Расход материалов: мешки — 180;
брус 60x200 — 20 пог. м; пленка полиэтиленовая — 25 м².

Затрата рабочей силы: насыпка мешков песком, подножка, укладка — 58 чел./час; бригадой в 8 человек при 10-часовой смене работа выполняется за 5,3 числ



Soviet population fatalities (surviving U.S. Strategic Forces).

After World War II, public attention was focused almost exclusively on the awesome destructive power of nuclear weapons. As a result, the industrial recovery of bombed cities such as Hiroshima went unnoticed. However, the fact that industry can and will recover from even nuclear devastation is evident from the published findings of the U.S. Strategic Bombing Survey of Hiroshima. The day after the explosion, bridges into downtown Hiroshima were open to traffic, and electric service was restored in some areas. On the second day, trains were again operating. By the third day, some streetcar lines resumed service. Within 9 days, telephone service was restored to the city center. In the outlying areas of the city, water, sewer, and gas services were never interrupted. When the U.S. survey team arrived 2 months after the explosion, the survivors were starting to erect dwellings on their original homesites.⁵

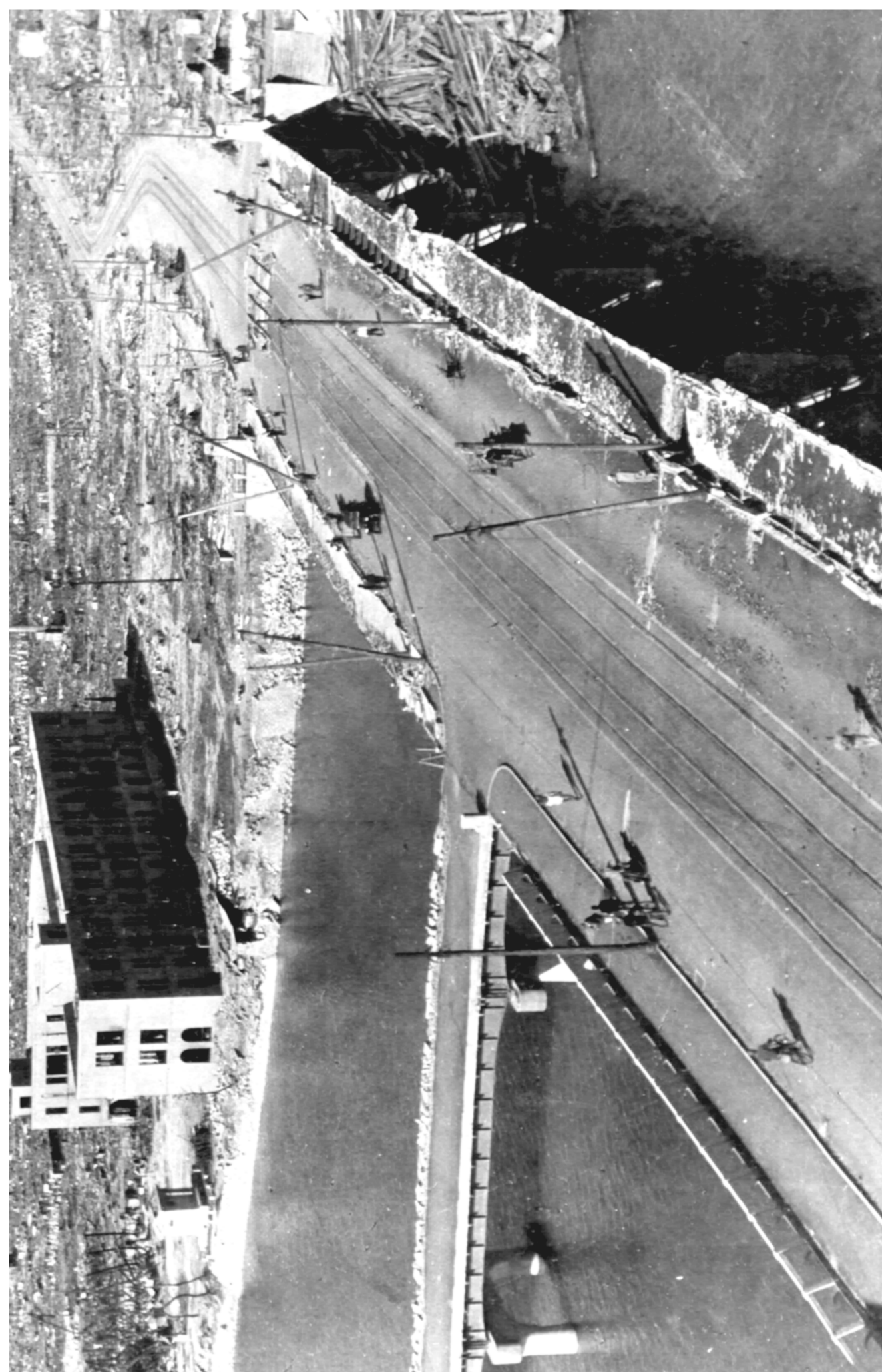
The main Messerschmitt plant at Augsburg was destroyed by over 500 tons of bombs. Thirty buildings and 70% of stored material were destroyed, but only one-third of the machine tools were damaged. Hence, production capacity was reduced by only 35%, and the plant was back in full production in little over 1 month.⁶

The Russians have themselves demonstrated that industrial buildings are not essential to continued production. To protect their aviation industry from German bomber attacks, the Soviets in 1941 used railroad cars to relocate approximately 1,523 industrial enterprises, including 1,360 large war plants, to the Trans-Volga, Urals, Eastern Siberia, and to Kazakhstan and Central Asia. This relocation involved 85% of the entire aviation industry. At many sites, resumption of production began even before temporary facilities were constructed. Machines were set up on temporary platforms in the open, and work was accomplished in weather that reached -40 degrees. Within a year, production rates exceeded the highest rates that had been achieved prior to the relocation.⁷

In order for Americans to judge the true position of the U.S. in a future nuclear confrontation, it is first necessary to establish some perspective as to how damaging a U.S. nuclear retaliatory strike might be to Soviet targets. Briefly summarized, the U.S./USSR survival capabilities are as follows. Given a first strike by the USSR, the U.S. would have on the order of half of its nuclear arsenal (ICBMs, SLBMs, and bombers) surviving. If these weapons were programmed to achieve maximum destruction of industrial targets, the entire U.S. surviving inventory could destroy unprotected people in, at most, 3% of Soviet territory. If the people were protected by simple, foxhole-type shelters, the lethal area that could be imposed by the U.S. surviving arsenal would be reduced to one-third of 1% of the Soviet land mass.[†]

[†]The calculations from which these figures are extracted have been furnished to the Committee at a higher classification.

Aioi Bridge, Hiroshima aiming point, survived



Intersection of Bridge 23 (Left) and Bridge 24 (Right). All Damage From Blast Effects. Bridge 23 (860 Feet to Gz, 2,170 Feet to Az). Bridge 24 (1,000 Feet to Gz, 2,230 Feet to Az).



720

Hiroshima zero point: damage was caused by charcoal stoves

Some critics argue that the Soviet evacuation and industrial protection plans are not viable because, if an evacuation was started, the U.S. could attack the evacuees before they could be fully dispersed. Such an argument is contrary to the U.S. objective of deterrence. It would be illogical for the United States to be in a position in which, to preserve the viability of its doctrine to deter war, its only recourse would be to preemptively attack the Soviet Union and accept the subsequent destruction of the United States.

The growing Soviet defensive and offensive superiority will most likely result not in nuclear war, but rather force the U.S. to make costly concessions to avoid nuclear war. In a future confrontation, should the Soviets execute their civil defense plans, the consequences to the U.S. of escalation to nuclear war would be disastrous, while the consequences might be tolerable to the Soviet Union. It is believed that the USSR could recover within no more than 2 to 4 years whereas the U.S. could not recover in less than 12 years. In such a condition, the so-called "balance of terror" would no longer be balanced.

Present Soviet civil defense capabilities require that the United States make some important policy decisions. One course of action would be to adhere to our present doctrine and try to make nuclear war as unthinkable for the Soviet Union as it now is for the United States. Another course would be to try to make nuclear war as survivable for the United States as it now is for the Soviet Union. There may be some middle ground between these two options.

Following the first course would imply an attempt by the U.S. to overpower the Soviet civil defenses. This would require a massive increase in the U.S. nuclear arsenal, or possibly a search for some new terror weapon that if used would really destroy all mankind. The second course would involve increased emphasis on defenses for the United States; probably some combination of air and civil defenses. Such defenses presumably would make nuclear war more thinkable for the U.S. and hence would be objectionable to some. However, unless we can be assured that nuclear war is unthinkable for the Soviet Union, it must be made survivable for the U.S.

. . . a civil defense program will permit the United States to maintain its security for less cost and with less nuclear weaponry than would otherwise be required.

REFERENCES

5. "The Effects of the Atomic Bomb on Hiroshima, Japan," U.S. Strategic Bombing Survey, Physical Damage Division, May 1947.
6. W.F. Craven, *The Army Air Forces in World War II*, Vol. III, University of Chicago Press, 1951, p. 42.
7. "The Relocation of the Soviet Aviation Industry During World War II: A Background Study," prepared by Major Walter Jajko, USAFR, DTS-1, for the Directorate of Soviet Awareness, June 1976.

Senator PROXMIRE. Well, now, as you may recall, one of the big arguments in finally defeating the ABM was the argument that you could always overcome any defensive measure, at least with respect to the ABM, with a far less expensive offense, in other words, \$10 spent in offense would overcome \$100 spent in defense, or something like that, roughly in that area.

Are you contending that civil defense wouldn't have anything like that, that it would be cheaper to provide defense in relationship to the offensive cost of overcoming it?

Mr. JONES. Yes, Senator. That is a very important question because it is true, as you have indicated, that the cost leverages against ABM are such that they can be cheaply overcome with offensive forces. Moreover, certain types of civil defenses are also not cost effective. For example, if the United States invested heavily in large population shelters within the cities, we believe it likely that the Soviet Union could overcome those at less cost than it took us to build them.

Some people have brought up the possibility that we would attack the evacuees before they could get away, but the whole deterrence theory is based on the hostage idea. If you blow up the hostage before he gets away, you have no more hostage. Moreover, your adversary is twice as angry at you. Therefore, for the United States to preemptively attack the Soviet evacuees when they start evacuating would be a very suicidal thing to do.

Senator PROXMIRE. Well, let me just say, what makes me hesitate on this—and I think Congressman Mitchell, too—is that our nuclear arsenal is so colossal, we are told that we have about 15 tons of TNT for every man, woman and child in the world, the equivalent in our nuclear power. The Administration has cut back the budget for civil defense. They haven't increased it; they have cut it back.

I don't know of anybody in the Defense Department—heaven knows they are concerned with the defense of our country; that is their responsibility—who is calling for a big, vigorous civil defense effort.

Is there anyone in the Defense Department that supports your view, any group? Or any defense experts outside the Defense Department who feels that we should consider engaging in this kind of ambitious and very expensive civil defense effort?

Mr. JONES. Yes, sir, I believe that there are a number of people who are concerned in the Department of Defense. They are concerned because they see an imbalance in vulnerability that could lead to a serious problem—despite the size of our nuclear arsenal. Regardless of how many tons of TNT we have for each man, woman and child, we nonetheless, if you look at how much of the Soviet territory our surviving weapons could damage, it is not much. It is only about 3 percent.

Going back to the previous point, I think a large amount of the Soviet civil defense preparation is multipurpose. It certainly can protect against the Chinese. It certainly can also protect against the United States.

I thought it was significant that the Soviets accelerated their civil defense preparations at about the time that we were signing the ABM treaty in 1972.

CIVIL DEFENSE AND THE STRATEGIC BALANCE

Civil defense is not of itself a threatening capability. Both Sweden and Switzerland have extensive and well-prepared civil defense programs. These programs do not threaten either the U.S. or the USSR because neither Sweden nor Switzerland possesses the offensive weaponry to seriously damage either of the two major powers. For this same reason, the Soviet civil defense preparations, although they date from before World War II, did not in earlier years threaten the United States.

However, in 1972 when the SALT I agreements were signed, it was publicly stated that the United States no longer had nuclear superiority; the forces of the two sides were at approximate parity. Since then, the Soviets have initiated concurrent deployment of four new ICBM models, creating serious concerns in the U.S. as to the trends in the strategic balance.

Paul H. Nitze has suggested that there are three different ways in which the strategic balance can be measured:

1. That which each side has *before* a strike
2. That *surviving* to the United States after an initial counterforce strike by the Soviet side
3. That remaining to each side *after an exchange*

167

ADDITIONAL QUESTIONS FOR THE RECORD

FOR

T.K. JONES

Question 1.

On what calculations do you base your estimate that 98% of the Soviet population would survive a massive countervalue attack with the entire U.S. arsenal of 8,500 or more nuclear warheads?

Answer

First, our estimate is based not on the "entire U.S. arsenal" but on the weapons that the U.S. could optimistically expect to survive a Soviet first strike.

168

The Soviet Union was assumed to have no antiballistic missile (ABM) defenses. Soviet air defenses were assumed to have been suppressed even though no U.S. warheads were assumed to be used for this purpose. All U.S. warheads (on SLBMs, bombers, and ICBMs) were assumed to be expended in a retaliatory strike on Soviet urban/industrial areas or on evacuation areas. (This latter assumption is particularly naive since it would leave the United States totally disarmed and leave Soviet military assets largely untouched.)

One fulfillment of this view was the October 1973 Middle East war, where a Soviet threat to intervene caused the United States to restrict deliveries to Israel, thereby bringing about the release of the encircled Egyptian army.

Marshal Grechko's view of the matter was that:

It was precisely the change in the correlation of forces in favor of socialism and the process of the relaxation of tension taking place on this basis which prevented the dangerous eruption of the war in the Near East from assuming dimensions threatening universal peace.

In Angola, the United States backed down with minimum protest and no effective counteractions. The Soviet leaders could logically view these events as an emerging tendency of the United States to back down in confrontations. Once such a pattern of concessions is established, it is increasingly difficult to halt the process.

As the correlation of forces shifts further in favor of the Soviet Union, it is not unrealistic to believe that the United States would be willing to back down in confrontations even more important than Angola and the Middle East. By 1978, the Soviet Union will have gained a "war-winning" capability comparable to that which the United States held in 1962 during the Cuban missile crisis. (See Figure A-3 of the study report.) The Soviets believe we have rational leadership and that the U.S. leadership, when placed at a major disadvantage, as the Soviets themselves were in 1962, can be forced to acquiesce to Soviets demands in future confrontations.

211

Question 24.

What evidence is available to indicate that the Soviet industrial defense measures have been implemented throughout the U.S.S.R. and are not merely "pilot" or "demonstration" programs at a few facilities?

Answer

Soviet civil defense literature and commentary by Soviet civil defense spokesmen over the past several years indicate this is not the case. Soviet newspapers and journals, especially the civil defense monthly, VOY ZNAN (circulation in excess of 300,000), refer to industrial defense measures underway at a broad variety of industry installations. Books such as Civil Defense of an Industrial Installation (2 editions totalling 500,000 copies) indicate nationwide programs.

THE UNITED STATES
STRATEGIC BOMBING SURVEY

THE EFFECTS
OF
THE ATOMIC BOMB
ON
HIROSHIMA, JAPAN

Volume I

Physical Damage Division

May 1947

a. Evidence relative to ignition of combustible structures and materials by heat directly radiated by the atomic bomb and by other ignition sources developed the following: (1) The primary fire hazard was present in combustible materials and in fire-resistive buildings with unshielded wall openings; (2) six persons who had been in reinforced-concrete buildings within 3,200 feet of air zero stated that black cotton black-out curtains were ignited by radiant heat; (3) a few persons stated that thin rice paper, cedar bark roofs, thatched roofs, and tops of wooden poles were afire immediately after the explosion; (4) dark clothing was scorched, and, in some cases, reported to have burst into flame from flash heat; (5) but a large proportion of over 1,000 persons questioned was in agreement that a great majority of the original fires was started by debris falling on kitchen charcoal fires, by industrial process fires, or by electric short circuits.

b. Hundreds of fires were reported to have started in the center of the city within ten minutes after the explosion. Of the total number of buildings investigated 107 caught fire, and, in 69 instances, the probable cause of initial ignition of the buildings or their contents was established as follows: (1) 8 by direct radiated heat from the bomb (primary fire), (2) 8 by secondary sources and (3) 53 by fire spread from exposing buildings.

14

3. Conditions on Morning of Attack

a. The morning of 6 August 1945 was clear with a small amount of clouds at high altitude. Wind was from the south with a velocity of about 4½ miles per hour. Visibility was 10 to 15 miles.

(1) Only a few persons remained in the air-raid shelters after the "all-clear" sounded.

84

G. CAUSE AND EXTENT OF FIRE

1. Conditions Prior to Attack

The city of Hiroshima was an excellent target for the atomic bomb from a fire standpoint: There had been no rain for three weeks; the city was highly combustible, consisting principally of Japanese domestic-type structures; it was constructed over flat terrain; and 13 square miles (including streets) of the 26.5-square-mile city was more than 5 percent built up (i. e., covered by plan areas of buildings). The remainder of the city comprised water areas, parks and areas built up below 5 percent. Sixty-eight percent of the 13-square-mile area was 27 to 42 percent built up and the 4-square-mile city center was particularly dense, 93.6 percent of it being 27 to 42 percent built up.



THE UNITED STATES
STRATEGIC BOMBING SURVEY

THE EFFECTS
OF
THE ATOMIC BOMB
ON
HIROSHIMA, JAPAN

Volume II

Physical Damage Division

Dates of Survey:

14 October–26 November 1945

Date of Publication

May 1947



PHOTO 36 IX. Shows partly burned coat of boy who was in open near City Hall (Building 28) 3,800 feet from AZ.

4. The city, consisting principally of Japanese domestic structures, was highly combustible and densely built up. Sixty-eight percent of the 13-square-mile city area was 27 to 42 percent built up and the 4-square-mile city center was particularly dense, 94 percent of it being 27 to 42 percent built up. All the large industrial plants were located on the south and southeast edges of the city.

8. Evidence relative to ignition of combustible structures and materials by directly radiated heat from the atomic bomb and other ignition sources was obtained by interrogation and visual inspection of the entire city. Six persons who had been in reinforced-concrete buildings within 3,200 feet of air zero stated that black cotton black-out curtains were ignited by flash heat. A few persons stated that thin rice paper, cedar bark roofs, thatched roofs, and tops of wooden poles were afire immediately after the explosion. Dark clothing was scorched and, in some cases, was reported to have burst into flame from flash heat. A large proportion of over 1,000 persons questioned was, however, in agreement that a great majority of the original fires were started by debris falling on kitchen charcoal fires. Other sources of secondary fire were industrial-process fires and electric short circuits.

9. There had been practically no rain in the city for about 3 weeks. The velocity of the wind on the morning of the atomic-bomb attack was not more than 5 miles per hour.

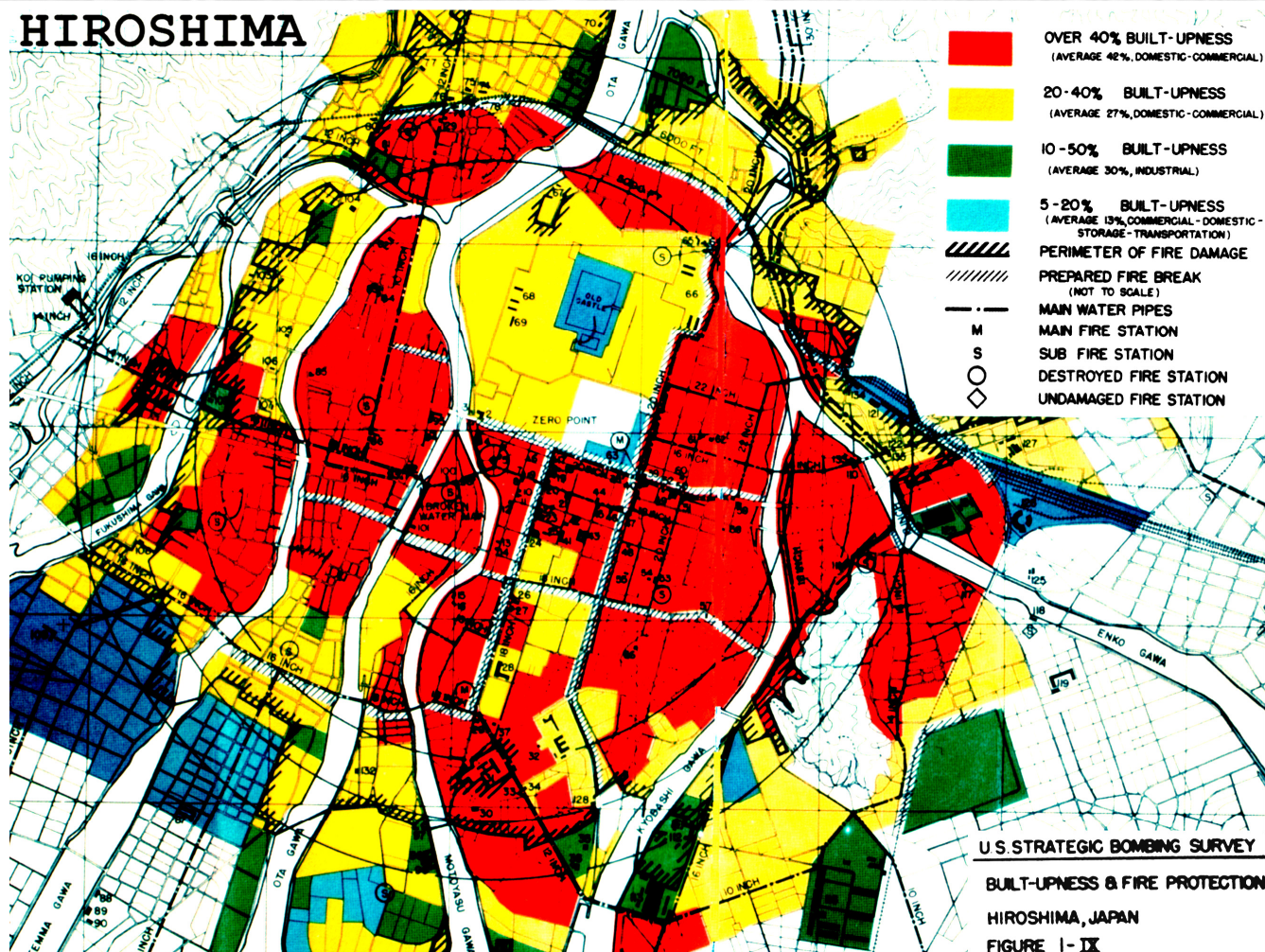
10. Hundreds of fires were reported to have started in the center of the city within 10 minutes after the explosion.

4

(8) Scores of persons throughout all sections of the city were questioned concerning the ignition of clothing by the flash from the bomb. Replies were consistent that white silk seldom was affected, although black, and some other colored silk, charred and disintegrated. Numerous instances were reported in which designs in black or other dark colors on a white silk kimono were charred so that they fell out, but the white part was not affected. These statements were confirmed by United States medical officers who had been able to examine a number of kimonos available in a hospital. Ten school boys were located during the study who had been in school yards about 6,200 feet east and 7,000 feet west, respectively, from AZ. These boys had flash burns on the portions of their faces which had been directly exposed to rays of the bomb. The boys' stories were consistent to the effect that their clothing, apparently of cotton materials, "smoked," but did not burst into flame. Photo 36 shows a boy's coat that started to smolder from heat rays at 3,800 feet from AZ.



HIROSHIMA



SOURCE: USSBS's report, "The Effects of the Atomic Bomb on Hiroshima, Japan," vol. 2

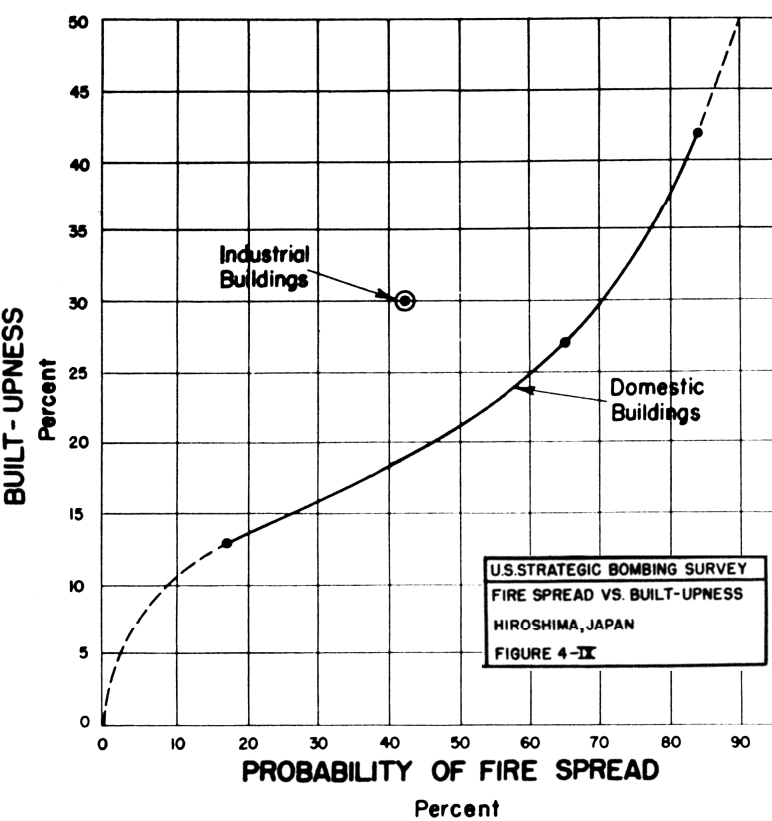
Only 8 of 64 non-wood buildings had thermal flash ignition evidence, 3 had blast damage induced fire, and 28 were ignited by firespread from wood homes.

D. THE CONFLAGRATION

1. Start of Fire

b. Direct Ignition by the Atomic Bomb. (1) Six persons were found who had been in reinforced-concrete buildings within 3,200 feet of AZ at the time of the explosion and who stated that black cotton black-out curtains were blazing a few seconds later. In two cases it was stated that thin rice paper on desks close to open windows facing AZ also burst into flame immediately, although heavier paper did not ignite. No incidents were recounted to the effect that furniture or similar objects within buildings were ignited directly by radiated heat from the bomb.

21



(4) It was reported that a cotton black-out curtain at an unprotected window in the east stair tower of Building 85 (3,800 feet from AZ) smoked and was scorched by radiated heat from the bomb but it did not burst into flames.

(5) A man who was in the third story of building 26 (3,000 feet from AZ) stated that radiated heat from the bomb ignited cotton black-out curtains at unprotected windows in the west wall and thin rice paper on desks.

(10) Fire fighting with water buckets was reported inside only four buildings (24, 33, 59, and 122) and probably prevented extensive fire damage in them. In Building 24, fire was started in contents of a room at the southwest corner of the second story by sparks from trees on the south side about 1½ hours after the attack. Men inside the building extinguished the fire and probably prevented further damage in the first and second stories (Photo 85). A little later, contents in the third story were ignited by sparks from the outside and were totally damaged. This fire was beyond control before it was discovered, but did not spread downward through open stairs. At Building 33, sparks from the west exposure, which burned in early evening, set fire to black-out curtains in the west wall and to waste paper in the fourth story of the northwest section of the building. Twenty persons were on guard in the building awaiting such an occurrence and the fires were quickly extinguished while in the incipient stage. At Building 59 sparks from the south exposure ignited a few pieces of furniture in the first and third stories and black-out curtains in the first story about 2 hours after the attack. These fires were extinguished by men inside and negligible damage resulted. A few window frames in the east and west walls and 2 or 3 desks in the first story of Building 122 were ignited by radiated heat and sparks from the west and northeast exposures. These fires were extinguished quickly and damage was negligible.

58

A. SUMMARY

4. The mean areas of effectiveness (MAE) of the atomic bomb for structural damage about ground zero (GZ) and the radii of the MAE's for the several classes of buildings present were computed to be as follows:

	MAE's in square miles	Radil of MAE's in feet
Multistory, earthquake-resistant.....	0. 03	500
Multistory, steel- and reinforced- concrete frame (including both earthquake- and non-earthquake- resistant construction).....	. 05	700
1-story, light, steel-frame.....	3. 4	5, 500
Multistory, load-bearing, brick-wall..	3. 6	5, 700
1-story, load-bearing, brick-wall.....	6. 0	7, 300
Wood-frame industrial-commercial (dimension-timber construction)....	8. 5	8, 700
Wood-frame domestic buildings (wood-pole construction).....	9. 5	9, 200
Residential construction.....	6. 0	7, 300

Building No.: 24. Coordinates: 5H. Distance from (GZ): 1,300, (AZ): 2,400.

NAME: Bank of Japan, Hiroshima branch.

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame (steel core).

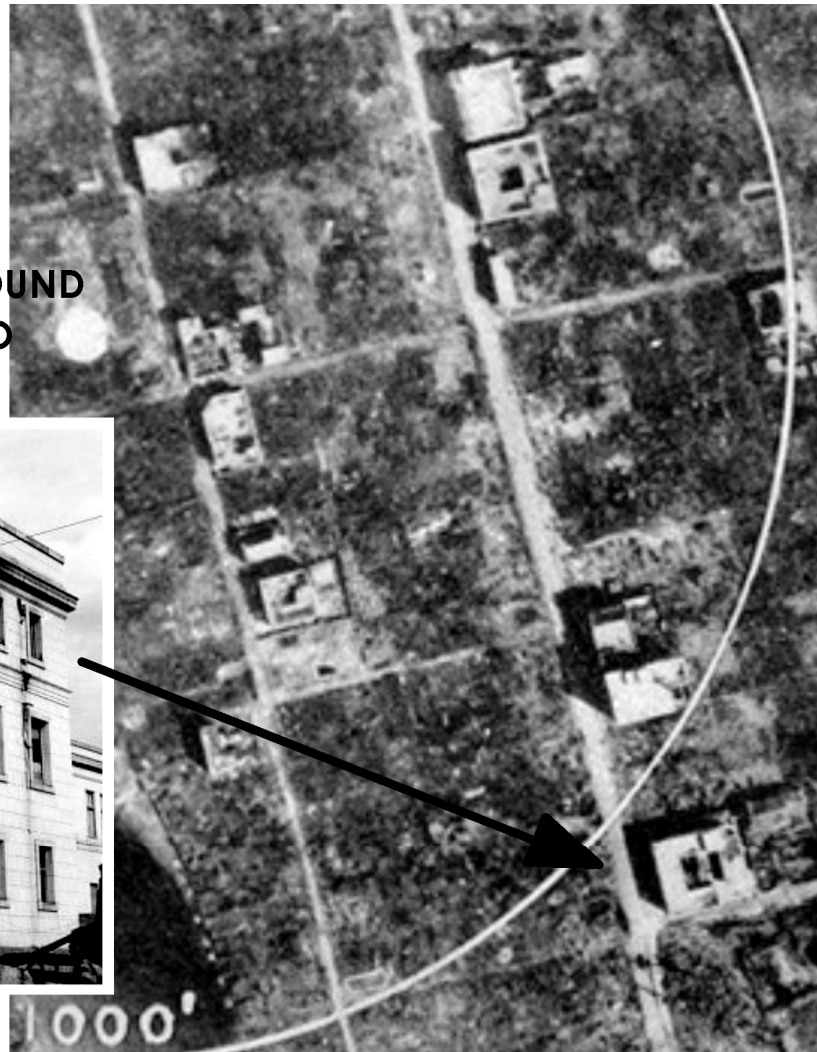
Walls: Reinforced concrete (12-inch) and stone (6-inch).

Floors: Reinforced concrete.

Framing: Reinforced concrete.

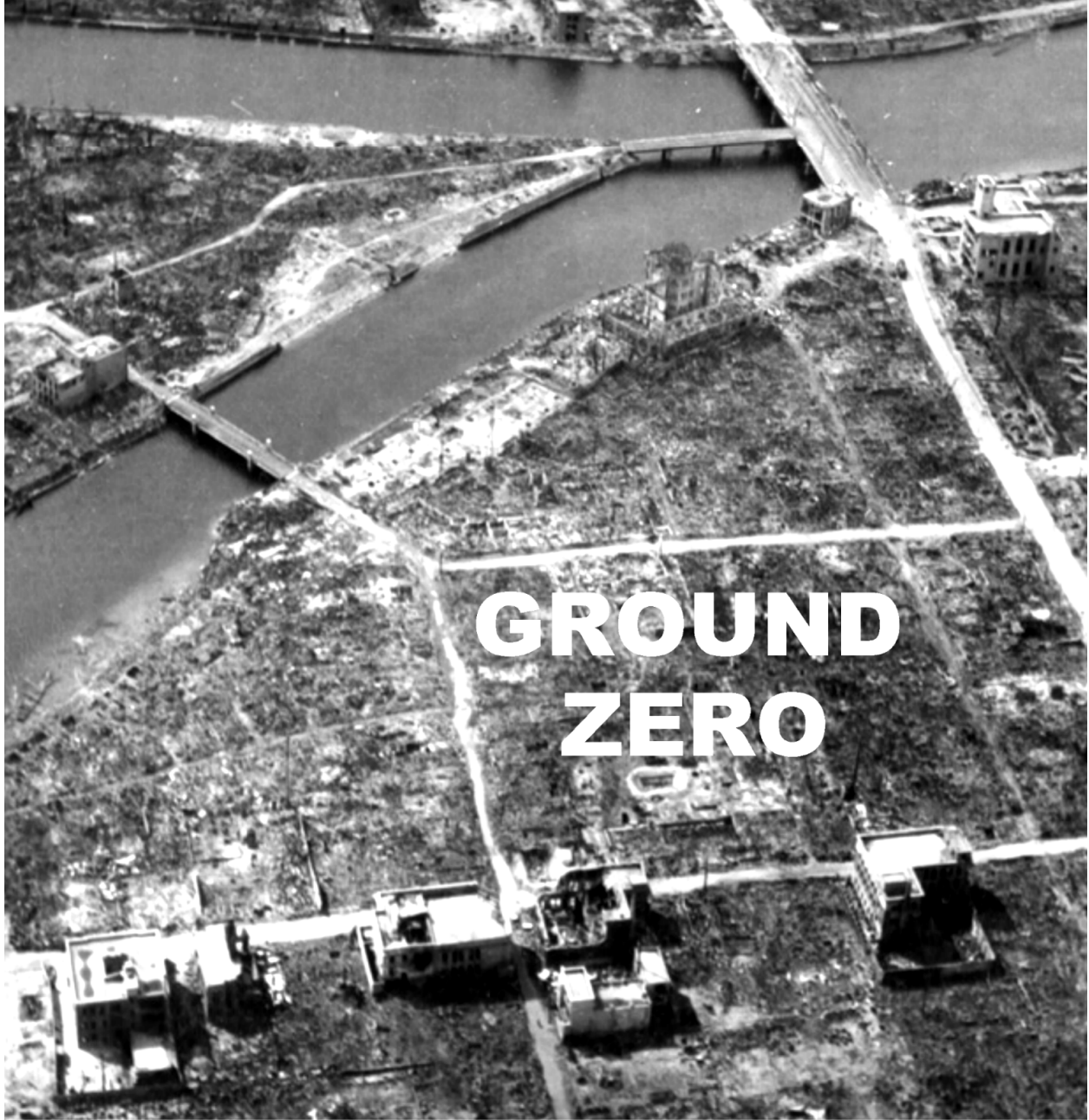
REMARKS: Fire only in room at southwest corner of second story and in entire third story. No fire in building right after bomb, but afire at 1000 hours. Fire in room in second story extinguished with water buckets.

**GROUND
ZERO**



U.S. Strategic Bombing Survey report 92





Concrete bridges and buildings survive near Hiroshima's ground zero



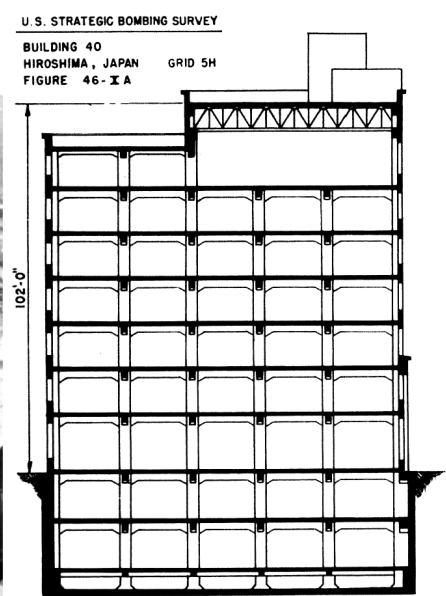
NAGASAKI SHELTERS. *Tunnel shelters in the hillside, such as the ones pictured (very close to ground zero), protected the few occupants from blast, heat, and radiation.*

Building No.: 26. Coordinates: 5H. Distance from (GZ): 2,300, (AZ): 3,000.
NAME: Chugoku Electric Co.
CONSTRUCTION AND DESIGN
Type: Reinforced-concrete frame.
Number of stories: 5 and basement and penthouse JTG class: E1.
Walls: Reinforced concrete (12-inch).

REMARKS: Fire throughout building except in 60 percent of basement (no fire in basement of west section and about 25 percent of east section). Man who was in third story stated that he saw cotton blackout curtains in west wall and thin paper on desks catch fire from flash of bomb. Fire was reported to have been in all stories 5 minutes after bomb.



Building No.: 40. Coordinates: 5H. Distance from (GZ): 2,500, (AZ): 3,200.
NAME: Fukuya Department Store.
CONSTRUCTION AND DESIGN:
Type: Reinforced-concrete frame.
Walls: 8-inch reinforced concrete—large windows.
REMARKS: Three persons who were questioned individually stated that this building was afire immediately or within 20 minutes after the bomb. One man who was in the building at the time stated that cotton blackout curtains in the west wall were smouldering immediately after the bomb. The entire building was afire at 1000 hours.



Building No.: 24. Coordinates: 5H. Distance from (GZ): 1,300, (AZ): 2,400.
NAME: Bank of Japan, Hiroshima branch.
CONSTRUCTION AND DESIGN
Type: Reinforced-concrete frame (steel core).
Walls: Reinforced concrete (12-inch) and stone (6-inch).
Floors: Reinforced concrete.
Framing: Reinforced concrete.

REMARKS: Fire only in room at southwest corner of second story and in entire third story. No fire in building right after bomb, but afire at 1000 hours. Fire in room in second story extinguished with water buckets.



Building No.: 33. Coordinates: 6H. Distance from (GZ): 5,300, (AZ): 5,600.
NAME: Hiroshima Postal Savings Bureau.
CONSTRUCTION AND DESIGN
Type: Reinforced-concrete frame.
Number of stories: 4 and basement. JTG class: E1.
Roof: Reinforced concrete, tile finish.
Partitions: Reinforced concrete.
Walls: Reinforced concrete, tile finish.

REMARKS: Sparks from west exposure ignited cotton black-out curtains in west wall at 2000 hours and waste paper in fourth story of northwest section at 2100 hours. Fires were extinguished with water buckets by 20 fire guards who were stationed inside. Fire damage to contents was negligible. Paper records stored in wood and steel racks in northeast section of building were exposed to direct radiated heat from bomb but did not catch fire.



Building No.: 86. Coordinates: 5G. Distance from (GZ): 2,000, (AZ): 2,800.
NAME: Kōkō Private Grammar School.
CONSTRUCTION AND DESIGN
Type: Reinforced concrete.
Number of stories: Three. JTG class: E1.
Roof: Reinforced-concrete slab.
Partitions: 9-inch brick and 6-inch reinforced concrete.
Walls: Reinforced concrete (8–10 inches).



Building No.: 59. Coordinates: 5I. Distance from (GZ): 4,100, (AZ): 4,500.

NAME: Geibi Bank Co., Hiroshima Branch (in use at time of bomb as the Higashi Police Station).

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame.

Walls: 8-inch reinforced concrete monolithic—medium window.

EXTENT OF FIRE: Total floor area: 16,200 square feet. Floor area burned: 0 square feet; 0 percent (after blast damage).

REMARKS: Sparks from south exposure ignited few pieces of furniture in first and third stories and cotton blackout curtains in first story about 1030 hours. Fires were extinguished with water buckets by people inside. Negligible fire damage resulted. Some of exposing buildings had just been removed prior to the bomb.



Building No.: 49. Coordinates: 5I. Distance from (GZ): 3,000, (AZ): 3,600.

Name: Chūgoku Newspaper.

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame.

Number of Stories: 7 and penthouse. JTG class: E1.

Roof: Reinforced-concrete beam and slab.

Partitions: Reinforced concrete—lath and plaster.

Walls: 7-inch reinforced concrete—large windows.

REMARKS: Man who was in building at time of bomb stated fire broke out in third and fourth stories immediately after bomb flash. Head bookkeeper in bank in Building 51 stated that there was fire in third story of Building 49, 10 minutes after bomb flash.



Building No.: 96. Coordinates: G5. Distance from (GZ): 400 (AZ): 2,000.

NAME: Taisho Clothing Store.

Walls: Reinforced concrete (10-inch)



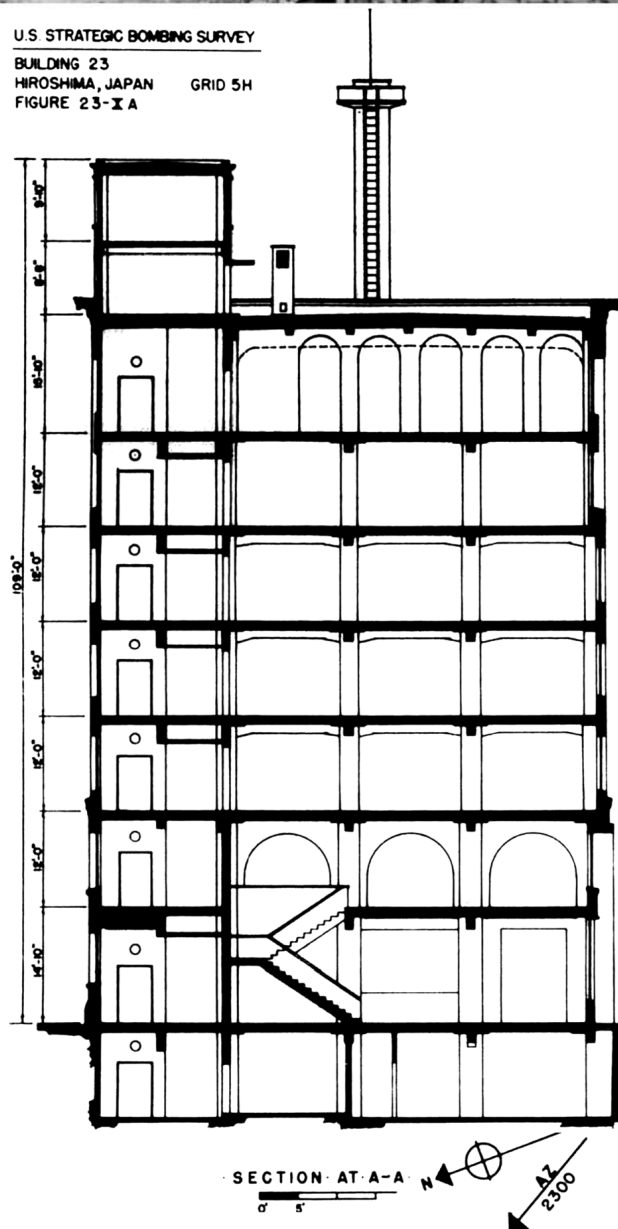
Building No.: 10 Coordinates: 5H. Distance from (GZ): 600, (AZ): 2,100.
NAME: Nippon Life Insurance Co., Hiroshima branch.
CONSTRUCTION AND DESIGN
Type: Load-bearing brick wall.
Number of stories: See drawing. JTG class: F2.
Roof: Reinforced-concrete slab 6 inch ($\frac{1}{4}$ -inch bars 6-inch oc by 12 inch oc).

Building No.: 23. Coordinates: 5H. Distance from (GZ): 1,200; (AZ): 2,300.
NAME: Fukoku Building.
CONSTRUCTION AND DESIGN
Type: Steel core reinforced-concrete frame.
Number of stories: 7 and basement. JTG class: E1.
Roof: Reinforced-concrete beam and slab (steel core).



U.S. STRATEGIC BOMBING SURVEY
 BUILDING 23
 HIROSHIMA, JAPAN GRID 5H
 FIGURE 23-X A

Building No.: 18. Coordinates: 5H. Distance from (GZ): 1,000, (AZ): 2,200.
NAME: Geibi Bank Co., Hiroshima Branch.
CONSTRUCTION AND DESIGN
Type: Reinforced-concrete frame.
Number of stories: 5 and $\frac{1}{2}$ basement. JTG class: E1.
Roof: Reinforced-concrete slab (metal pan).
Partitions: Reinforced-concrete (5-inch). Wood lath and plaster in rear addition.
Walls: Reinforced concrete (10-inch).



U. S. STRATEGIC BOMBING SURVEY

PHYSICAL DAMAGE DIVISION

Field Team No. 1, Hiroshima, Japan

Building No.: 5. Coordinates: 5H. Distance from (GZ): 100, (AZ): 2,000. Number of stories: 1. JTG class: A 2-3.
NAME: Shima Surgical Hospital. Roof: Tile over wood on wood truss.
CONSTRUCTION AND DESIGN Partitions: Plaster on wood lath and studs.
Type: Bearing wall. Walls: Brick-bearing, 18 inches.



Building No.: 6. Coordinates: 5H. Distance from (GZ): 600, (AZ): 2,100. Number of stories: Three and basement. JTG class: E1.
NAME: Chiyoda Life Insurance Co., Chugoku branch. Roof: Reinforced-concrete beam and slab-tile covered.
CONSTRUCTION AND DESIGN Partitions: Reinforced-concrete, major—metal lath and plaster, minor.
Type: Reinforced-concrete frame. Walls: Reinforced-concrete panels, 10 inches. Reinforced-concrete granite facing.



U. S. STRATEGIC BOMBING SURVEY

PHYSICAL DAMAGE DIVISION

Field Team No. 1, Hiroshima, Japan

BUILDING ANALYSIS

SHEET No. 1

Building No.: 24. Coordinates: 5H. Distance from (GZ): 1,300, (AZ): 2,400.
 NAME: Bank of Japan, Hiroshima branch.
CONSTRUCTION AND DESIGN
 Type: Reinforced-concrete frame (steel core).
 Number of Stories: 3 and basement. JTG class: E1.
 Roof: Reinforced-concrete beam and slab.
 Partitions: Reinforced concrete and wood lath.
 Walls: Reinforced concrete (12-inch) and stone (6-inch).
 Floors: Reinforced concrete.
 Framing: Reinforced concrete.
 Window and door frames: Metal (exterior) wood (interior). Ceilings: Plaster on concrete.
 Condition, workmanship, and materials: Excellent.
 Compare with usual United States buildings: Much stronger—steel core construction.

OCCUPANCY: Bank.

CONTENTS: Bank and office equipment furnishings.

DAMAGE to building: Only minor damage—top story burned out, partitions, sash, trim blown out in two lower stories.

Cause: Fire.

To Contents: Destroyed in third story—moderate debris and blast damage in first and second stories, none in basement.

Cause: Fire and debris (about equally).

TOTAL FLOOR AREA (square feet): 32,800. Structural damage: —. Superficial damage:

FRACTION OF DAMAGE: Building structural: —. Superficial: —. Contents: 30 percent.

REMARKS: Glass removed from skylight (20 by 20 feet) and light steel-frame structure and roof covered with 12 to 18 inches of sand and cinders.

NOTE.—Building damage based on total floor area. Contents damage is fraction of contents seriously damaged.

SHEET No. 2

(Fire Supplement to Sheet No. 1)

Building No.: 24. Fire classification: R.

WALL OPENINGS: Shutters: Steel rollers.

Shut: Part.

Effect of blast: Blown in.

FLOOR OPENINGS:

	Enclosed	Fire doors	Automatic	Effect of blast
Stairs:	Part	Steel rollers	No	None—doors open.
Elevators:	Yes	Metal and W. G.	No	Bent.

EXPOSURE:

Location	Distance	Firebreak Clearance	Fire Class	Fire Burned	Remarks
N	25'	No	C	Yes	14-foot concrete wall between.
E	25'	No	R	Yes	Building 25 (14-foot wall between).
S	—	No	—	—	No exposure.
W	125'	Yes	C	Yes	

PROBABLE CAUSE OF FIRE: Fire spread from exposures.

VERTICAL FIRE SPREAD: No.

EXTENT OF FIRE: Total floor area: 32,800 square feet. Floor area burned: 5,200 square feet; 16 percent (after blast damage).

REMARKS: Fire only in room at southwest corner of second story and in entire third story. No fire in building right after bomb, but afire at 1000 hours. Fire in room in second story extinguished with water buckets.



U. S. STRATEGIC BOMBING SURVEY

PHYSICAL DAMAGE DIVISION

Field Team No. 1, Hiroshima, Japan

BUILDING ANALYSIS

SHEET No. 1

Building No.: 59. Coordinates: 5I. Distance from (GZ): 4,100, (AZ): 4,500.

NAME: Geibi Bank Co., Hiroshima Branch (in use at time of bomb as the Higashi Police Station).

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame.

Number of stories: See sketch. JTG class: E1.

Roof: Reinforced-concrete beam and slab.

Partitions: 7-inch reinforced concrete.

Walls: 8-inch reinforced concrete monolithic—medium window.

Floors: Reinforced-concrete beam and slab—parquet and tile.

Framing: Reinforced-concrete beam and slab.

Window and door frames: Steel. Ceilings: Sheet metal on wood framing.

Condition, workmanship and materials: Good.

Compare with usual United States buildings: Appreciably stronger than United States design.

OCCUPANCY: Police station (office).

CONTENTS: Office equipment.

DAMAGE to building: Minor damage only—sash blown out and hung ceilings partially stripped.

Cause: Blast.

To contents: Slight damage to contents from blast and debris.

Cause: Blast.

TOTAL FLOOR AREA (square feet): 16,200. Structural damage: —. Superficial damage:

FRACTION OF DAMAGE: Building. Structural:

Superficial: Contents: 10 percent.

REMARKS:

NOTE.—Building damage based on total floor area. Contents damage is fraction of contents seriously damaged.

SHEET No. 2

(Fire Supplement to Sheet No. 1)

Building No.: 59. Fire classification: R.

WALL OPENINGS: Shutters: Steel rollers in east wall and third story of south and west walls (wired glass in all windows).

Effect of blast: Blown in at west wall, bent at south wall.

FLOOR OPENINGS:

	Enclosed	Fire doors	Auto matic	Effect of blast
Stairs:	Yes	Metal	No	Bent slightly.
Elevators:				

EXPOSURE:

		Firebreak	Fire	
Location	Distance	Clearance	Class	Burned
N	150'	Yes	C	Yes
E	60'	Yes	C	Yes
S	30'	Partial	C	Yes
		100'		
W	60'	Yes	C	Yes

All exposures burned.

PROBABLE CAUSE OF FIRE: Fire spread from exposures.

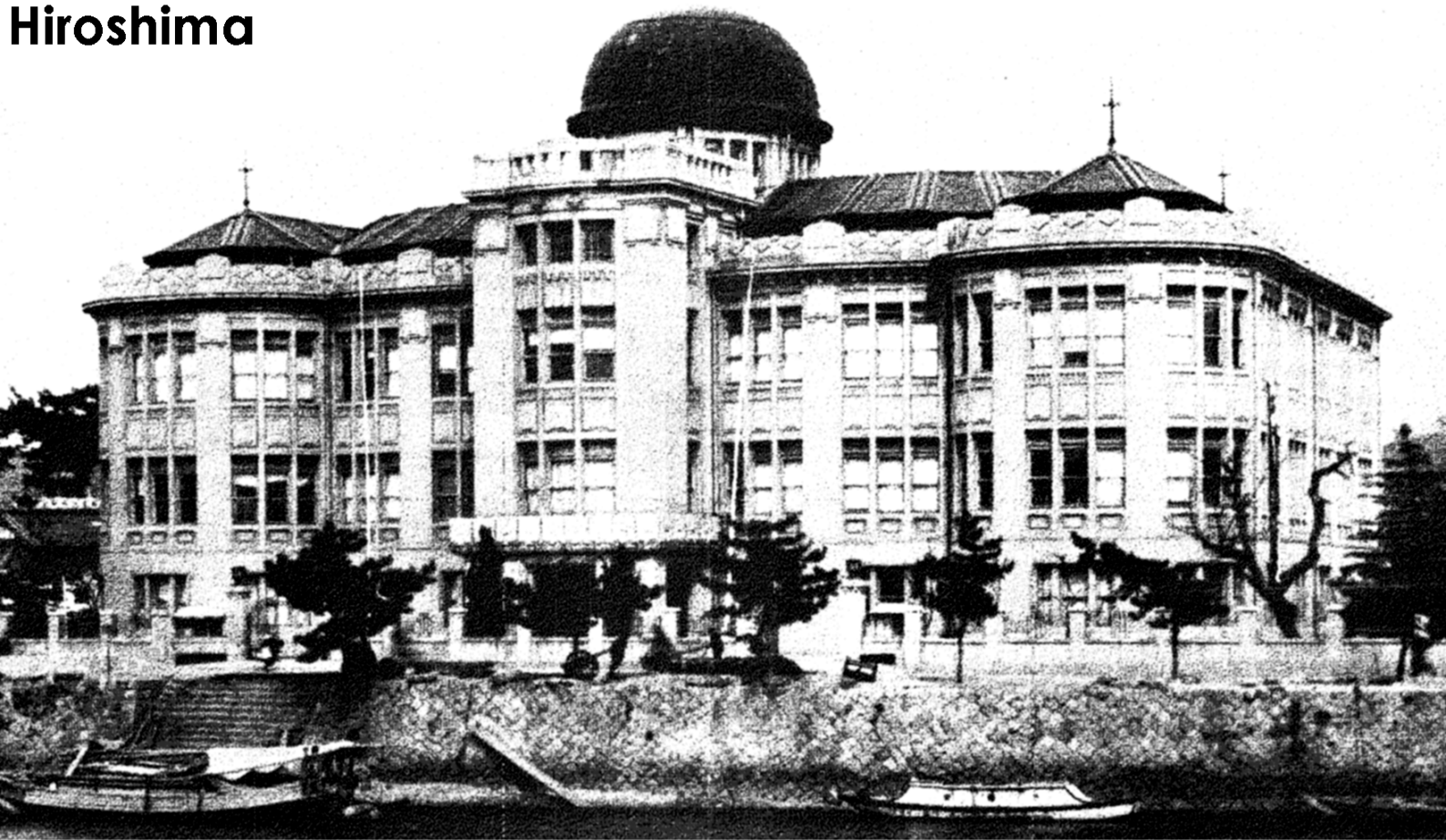
VERTICAL FIRE SPREAD: No.

EXTENT OF FIRE: Total floor area: 16,200 square feet. Floor area burned: 0 square feet; 0 percent (after blast damage).

REMARKS: Sparks from south exposure ignited few pieces of furniture in first and third stories and cotton blackout curtains in first story about 1030 hours. Fires were extinguished with water buckets by people inside. Negligible fire damage resulted. Some of exposing buildings had just been removed prior to the bomb.



Hiroshima



Commercial Museum (300 meters) before and after



BANK OF JAPAN BUILDING AFTER ATTACK ON HIROSHIMA



GEIBI BANK CO. BUILDING AFTER ATTACK ON HIROSHIMA

Bank of Japan: USSBS Building 24, 1300 ft from GZ
 Geibi Bank Co: USSBS Building 59, 4100 ft from GZ
 (Table 5 of USSBS report 92 Hiroshima, v2.)

In both, survivors extinguished fire with water buckets.
 (Ref: Panel 26 of the "DCPA Attack Environment Manual", Chapter 3.)

Secondary Fires

Secondary fires are those that result from airblast damage. Their causes include overturned gas appliances, broken gas lines, and electrical short-circuits. McAuliffe and Moll (Reference 1) studied secondary fires resulting from the atomic attacks on Hiroshima and Nagasaki and compared their results with data from conventional bombings, explosive disasters, earthquakes, and tornadoes. Their major conclusion was that secondary ignitions occur with an overall average frequency of 0.006 for each 1000 square feet of floor space, provided airblast peak overpressure is at least 2 psi. The frequency of secondary ignitions appears to be relatively insensitive to higher overpressures.

Based on surveys of Hiroshima and Nagasaki buildings.

FREQUENCY OF SECONDARY IGNITIONS AS A FUNCTION OF BUILDING TYPE

<u>Type of Structure</u>	<u>Frequency of Secondary Ignitions (for each 1,000 square feet of floor area)</u>
Wood	0.019
Brick	0.017
Steel	0.004
Concrete	0.002

MULTIPLYING FACTOR FOR TYPES OF BUILDING OCCUPANCIES

<u>Type of Occupancy</u>	<u>Multiplying Factor</u>
Public	0.4
Mercantile	0.5
Residential	0.5
Manufacturing	1.0
Miscellaneous	10.0

MULTIPLYING FACTOR FOR TIME OF DAY

<u>Time of Day</u>	<u>Multiplying Factor</u>
Night	0.5
Day (other than mealtimes)	1.0
Mealtimes	2.0

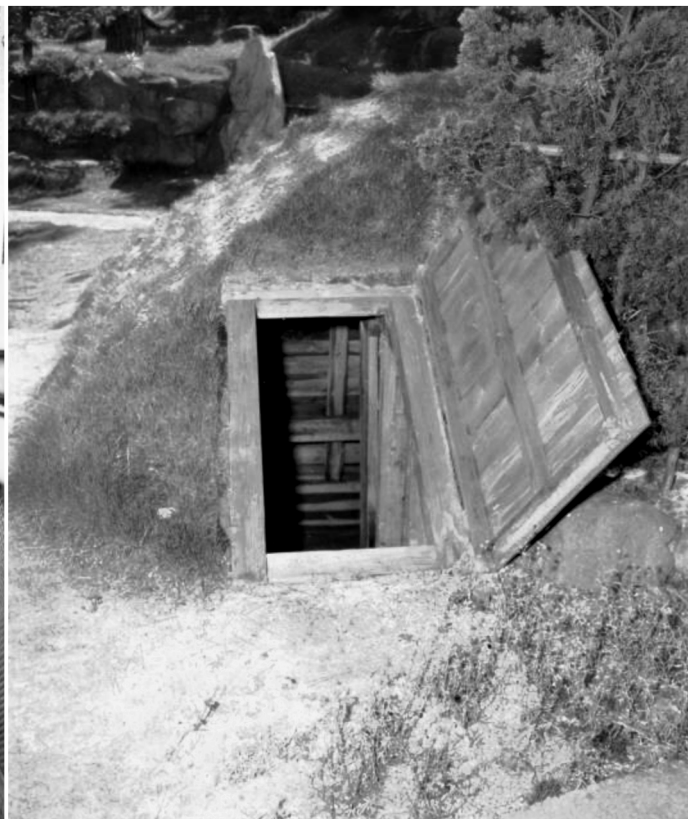
1 . Secondary Ignitions in Nuclear Attack, J. McAuliffe and K. Moll, Stanford Research Institute, Menlo Park, California 94025, SRI Project 5106 (AD 625173), July 1965.

Type 3 outdoor Anderson shelter

Anderson shelters exposed to Operation Hurricane nuclear test



Anderson shelter with earth cover (not sandbags) and radiation-shielded entrance at Home Defence College, Easingwold, York, 1980.

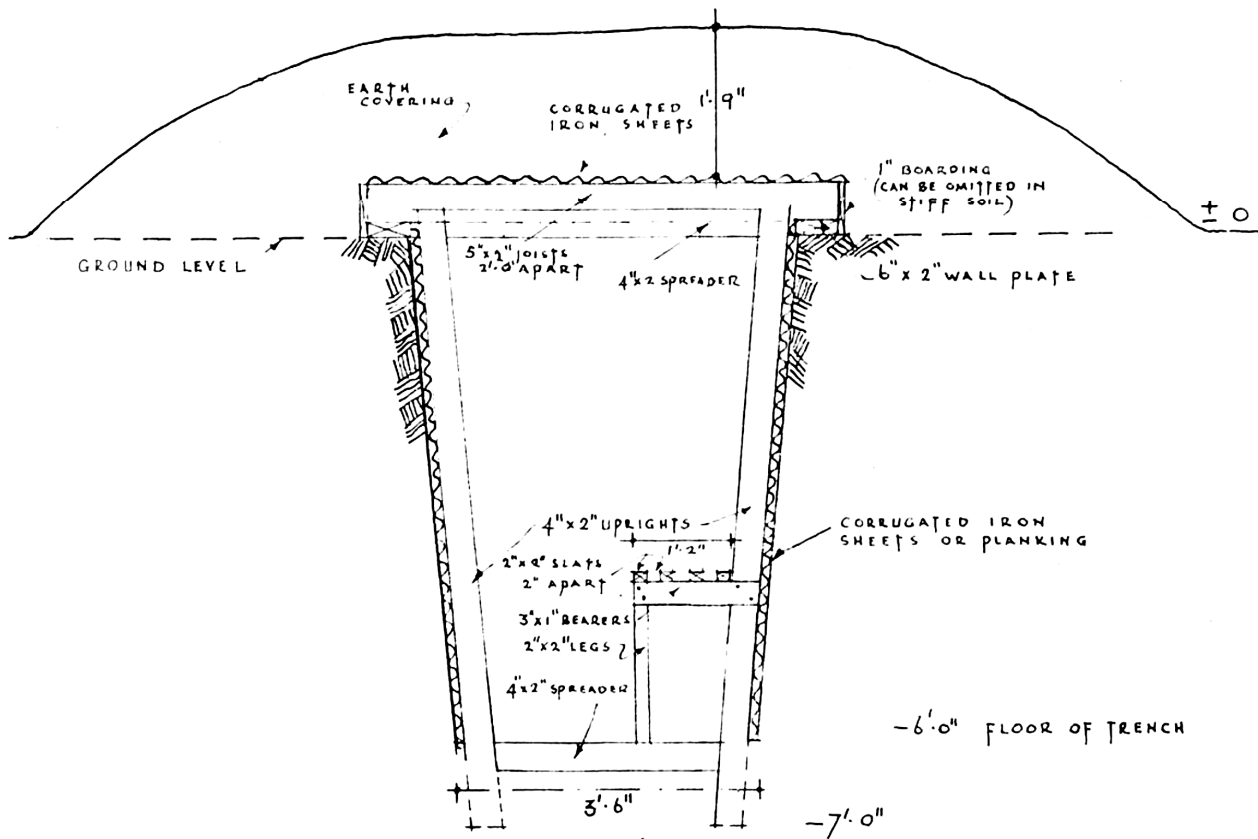


Earth covered shelter, Hiroshima (U.S. Strategic Bombing Survey)



GARDEN TRENCH SHELTER

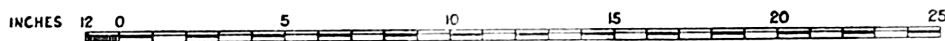
HOME OFFICE A.R.P. DEPARTMENT



National Archives: HO45 / 17590 Nissen corrugated steel shelter 1938

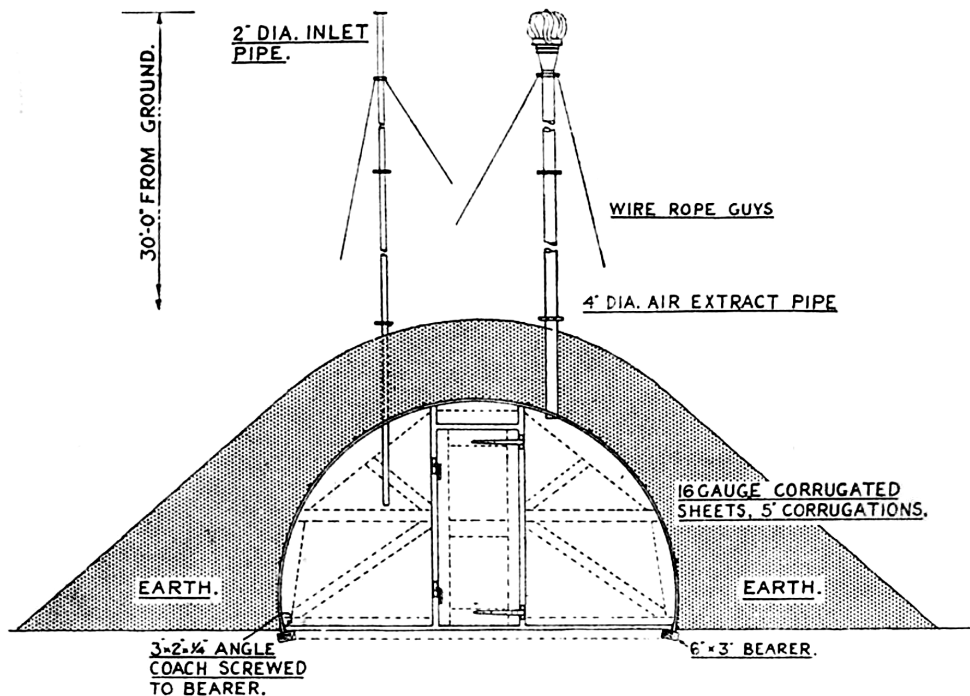
THE NISSEN AIR RAID SHELTER

CAPACITY 50 PERSONS.



SCALE OF FEET.

PATENT APPLIED FOR IN CONNECTION WITH VENTILATING PIPES.



ANDERSON SHELTER TESTS AGAINST 25 KT NUCLEAR
NEAR SURFACE BURST (2.7 METRES DEPTH IN SHIP)

AWRE-T1/54, 27 Aug. 1954

SECRET—GUARD

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

(formerly of Ministry of Supply)

SCIENTIFIC DATA OBTAINED AT OPERATION HURRICANE

(Monte Bello Islands, Australia—October, 1952)

12.1. Blast Damage to Anderson Shelters

At 1,380 feet, Fig. 12.1, parts of the main structure of the shelters facing towards and sideways to the explosion were blown in but the main structure of the one facing away from the explosion was intact, and would have given full protection. At 1,530 feet, Fig. 12.2, the front sheets of the shelter facing the explosion were blown into the shelter but otherwise the main structures were more or less undamaged, as were those at 1,800 feet, Fig. 12.3.

Operation Hurricane nuclear test Anderson shelters used sandbags which gave no "earth arching" protection, unlike packed soil cover used over London Anderson shelters, 1940:



13. THE PENETRATION OF THE GAMMA FLASH

13.1. *Experiments on the Protection from the Gamma Flash afforded by Slit Trenches*

13.1.1. The experiments described in this section show that slit trenches provide a considerable measure of protection from the gamma flash. From the point of view of Service and Civil Defence authorities this is one of the most important results of the trial.

13.1.2. Rectangular slit trenches 6 ft. by 2 ft. in plan and 6 ft. deep were placed at 733, 943 and 1,300 yards from the bomb and circular fox holes 2 ft. in radius and 6 ft. deep were placed at 943 and 1,300 yards.

The doses received from the flash were measured with film badges and quartz-fibre dosimeters in order to determine the variation of protection with distance, with depth and with orientation of the trench and the relative protection afforded by open and covered trenches.

In general, the slit trenches were placed broadside-on to the target vessel but at 1,300 yards one trench was placed end-on. Two trenches, one at 733 and one at 943 yards were covered with the equivalent of 11 inches of sand.

TABLE 13.1

Variation of Gamma Flash Dose on Vertical Axis of Trench

Type of trench	Rectangular broadside-on open			Rectangular end-on open	Circular open		Rectangular broadside-on covered	
	1,300	943	733	1,300	1,300	943	943	733
Distance (yards) ...	1,300	943	733	1,300	1,300	943	943	733
Surface dose (Roentgens)	300	3,000	14,000	300	300	3,000	3,000	14,000
Depth below ground level (inches)								
6 ...	150	1,000	—	230	214	1,200	(75)	—
12 ...	75	430	—	150	120	545	47.6	—
24 ...	33.3	150	584	60	54.5	188	25	(140)
36 ...	23	70	216	31.6	30	86	13	(56)
48 ...	(20)	43	100	20	17.7	48.5	7.7	(31)
60 ...	—	(37.5)	61	13.6	10.7	(33.3)	5	(23)
72 ...	—	—	(46.7)	(8.6)	7	—	(3.5)	—

Entries in brackets are extrapolations or estimates.

It cannot be too strongly emphasised that it is most important, from the point of view of reducing casualties as a whole, for everyone in an area under attack to make use of any shelter that is available. Recent research has shown that there would be less fatal casualties if everyone were in relatively poor shelter than if half the population were in shelter twice as good and the other half remained in the open.

THE RISK OF BECOMING A CASUALTY

(Basic Methods of Protection Against High Explosive Missiles - Manual of Basic Training, Civil Defence, vol. 2, Pamphlet 5, H.M.S.O., 1951)

**STANDING IN
THE OPEN OR
IN A STREET**

**LYING DOWN
IN THE OPEN
OR IN A
STREET**

**LYING BEHIND
LOW COVER OR
IN A DOORWAY**

**SHELTER IN A
BRICK HOUSE
AWAY FROM
WINDOWS**

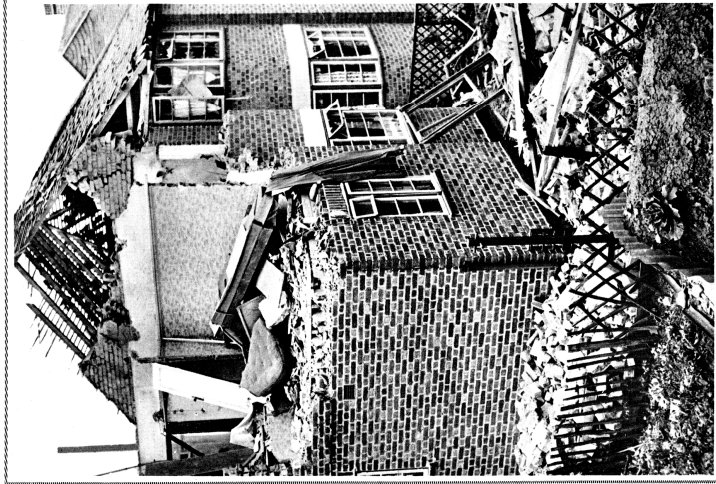
**IN TRENCHES,
GOOD SURFACE
SHELTERS, OR
STRUTTED
BASEMENTS**



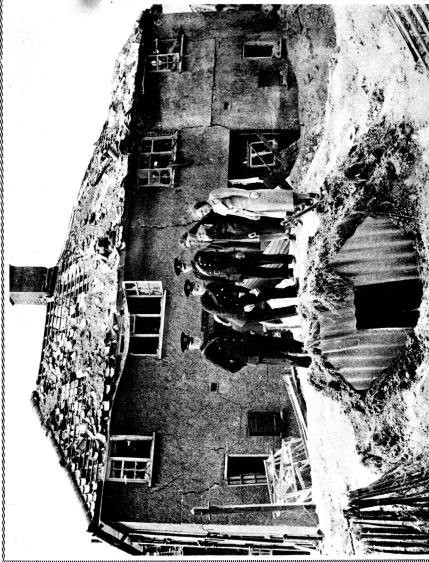
IN SHELTER



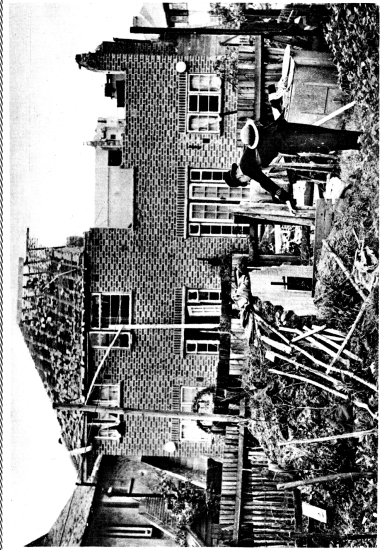
AFFORDING STRIKING PROOF OF THE EFFICACY OF ANDERSON SHELTERS: ALMOST MIRACULOUS ESCAPES IN MIDLAND AND SOUTH OF ENGLAND HOMES.



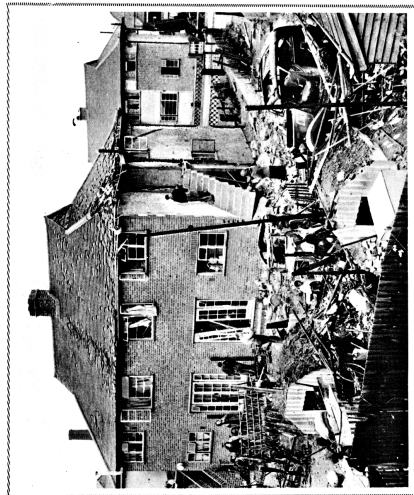
AN ANDERSON SHELTER, CORRECTLY COVERED WITH EARTH (FROM WHICH CABBAGES SPROUT), UNHARMED DESPITE SURROUNDING BOMB DAMAGE. (Wide World.)



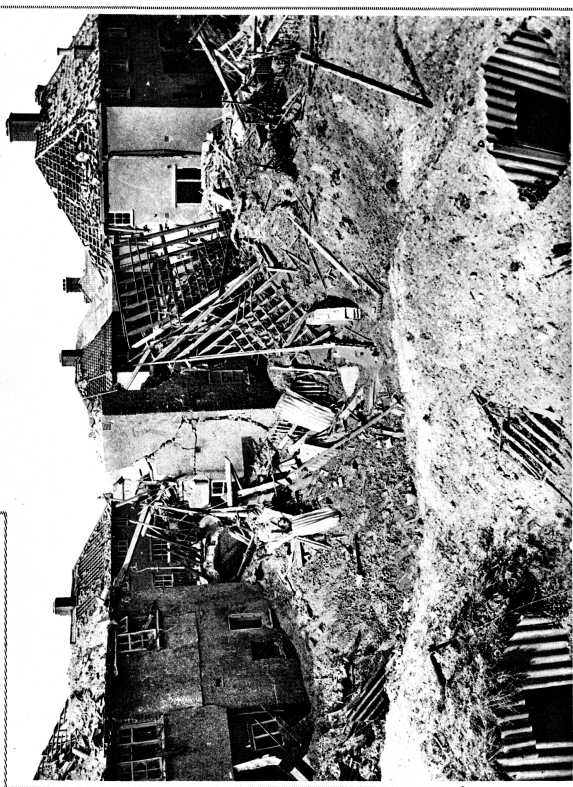
DAMAGED HOUSES, WITH AN UNTOUCHED ANDERSON SHELTER IN THE FOREGROUND, WHOSE OCCUPANTS TEND COMPLETE SAFETY. (Planet.)



INTACT AMONG THE DEBRIS CAUSED BY GERMAN BOMBS: AN ANDERSON SHELTER IN A S.W. LONDON SUBURB. (Planet.)



TWO ANDERSON SHELTERS IN THE SAME DISTRICT AS THAT SHOWN IN THE PHOTOGRAPH ON THE LEFT, ALSO INTACT. (Planet.)



A CRATER, 35 FT. DEEP, OUTSIDE A DAMAGED HOUSE IN CROYDON. ALL THE OCCUPANTS OF THE SHELTERS ESCAPED INJURY. (Topical.)



GIVING THE LIE TO GOBBELS: MRS. E. CULLEN SMILINGLY LEAVING THE EMERGENCY EXIT—A BOMB HAVING BLOCKED THE SHELTER ENTRANCE. (Planet.)

THE violent and very expensive raids by the Luftwaffe in the week ending August 17 provided a striking demonstration of the efficacy of the Anderson shelter when it has been properly covered with earth and the entrance adequately screened. Both at Croydon and in the Midlands its value was proved. When a bomb dropped in the middle of a Midland town, three families of all escaped unhurt. Seven people taking cover in a home-made shelter, however, were killed. Seven persons sheltering in an Anderson shelter in another Midland area were unharmed by a bomb which fell on a housing estate. Six of nine bombs fell on a council house, but the occupants were in their Anderson shelter, less than ten yards away, and were unharmed. One man in South London, with his family, was unharmed by a bomb which fell from Folkestone, said that they were in an Anderson shelter during the raid on August 18 when five bombs fell within a distance of 100 yards. "Our little shelter trembled," he said, "but we suffered no shock and no damage. In the South-Western suburbs were injured by bomb splinters penetrating the back of the shelter, which was not completely covered with earth.



A LARGE BOMB-CRATER BEHIND A ROW OF DAMAGED HOUSES AFTER THE CROYDON RAID: THE SHELTERS WERE UNAFFECTED. (Keytime.)

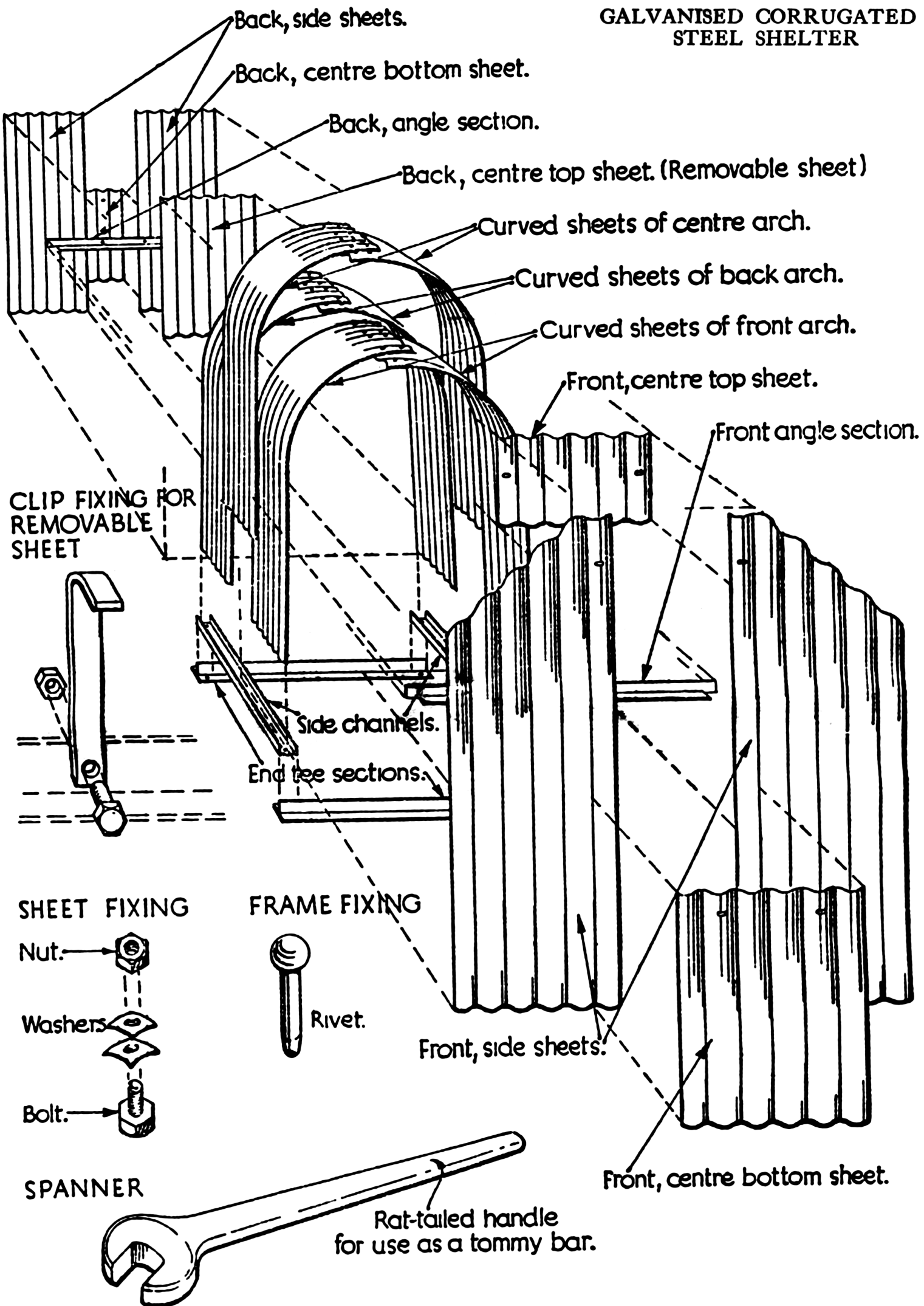


AN UNDAUNTED MIDLAND FAMILY, DUG OUT AFTER A BOMB HAD BURST BEHIND THEIR SHELTER—WHICH SAVED THEM. (A.P.)



HARDLY THE "COWERING" LONGFLEET OF DR. GOBBELS' IMAGINATION: A CHEERFUL NORTHFLEET FAMILY SITTING BY THEIR SHELTER AFTER A RAID. (Fox.)

GALVANISED CORRUGATED STEEL SHELTER



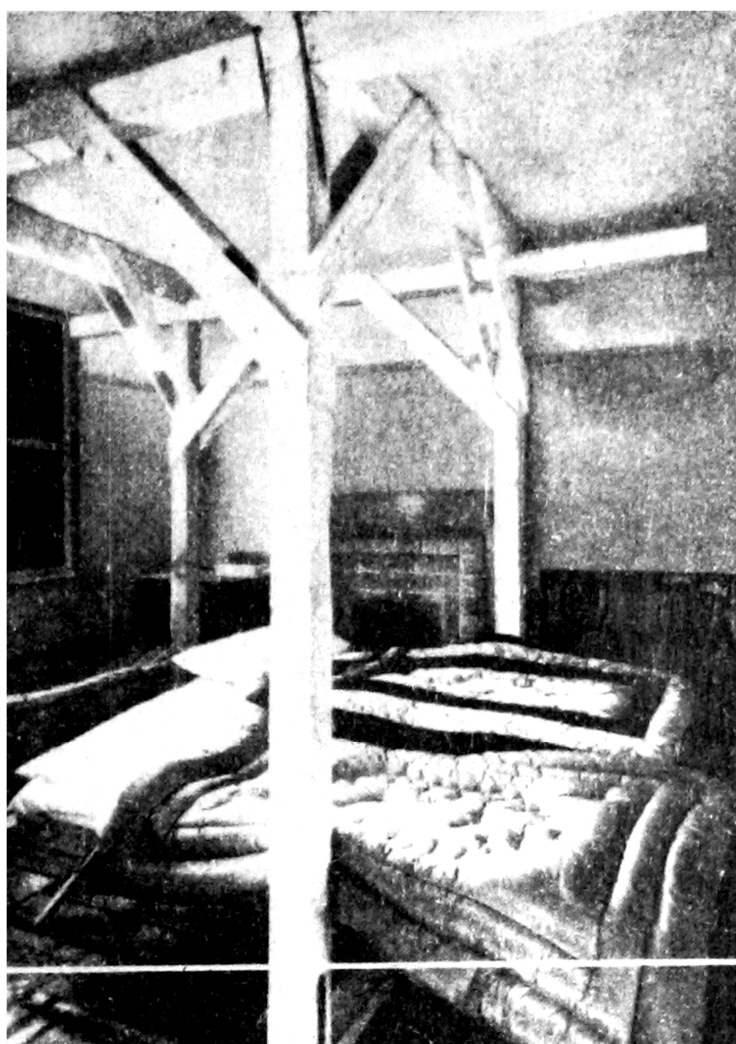
ANDERSON SHELTER



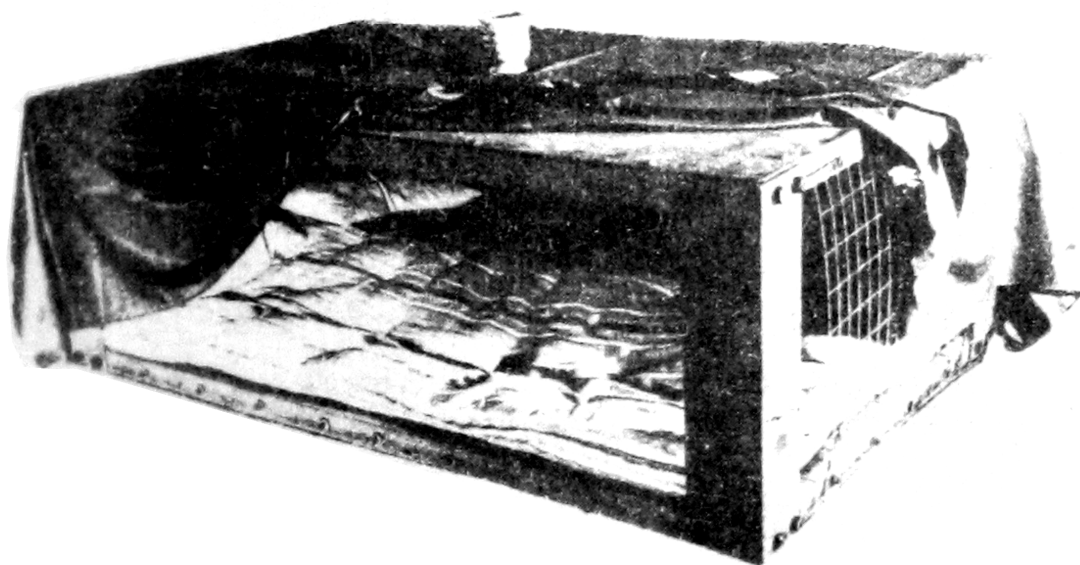
ILLUSTRATED LONDON NEWS—Aug. 24, 1940

GIVING THE LIE TO GOEBBELS: MRS. E. CULLEN SMILINGLY LEAVING THE EMERGENCY
EXIT—A BOMB HAVING BLOCKED THE SHELTER ENTRANCE. (*Planet.*)

June 1941



SHELTER at home



3d.

ISSUED BY THE MINISTRY OF HOME SECURITY
AND PUBLISHED BY H.M. STATIONERY OFFICE

Introduction

Not everyone wants to leave home for shelter. Some people can't. Lots of people just prefer to remain in their own house anyway. This inclination is a natural one. It is a sound instinct too, if some protection can be found against the collapse of walls and ceilings.

Shelter indoors allows you to sleep at night in reasonable security and in the warmth and comfort of your house. It also provides handy cover should there be a sudden raid in the day time.

A direct hit cannot be guarded against in any form of home shelter, but the risk of such a direct hit is very small compared with that of a bomb bursting near enough to damage the house or to demolish it. Protection can be obtained in a house even if a bomb demolishes most of it.

The walls, floors and roof of an ordinary house give quite a lot of protection against splinters and blast from a bomb. The idea of an indoor shelter is to make use of this protection and to add safeguards against the other effects of bombs.

The chief of these is the danger of the house falling down. People have often been rescued unhurt from the ruins of demolished houses because they had taken shelter under staircases, or tables, that had by chance been strong enough to protect them from the falling ruins of the house. The chief purpose of the indoor shelters described in this pamphlet is to protect the occupants against injury when the bedroom floor, the roof and other débris fall on them.

They do not provide such easy emergency escape as a garden shelter, but if you are trapped they protect you from the débris till the Rescue Party releases you. Very often, however, though the house has fallen you will be able to release yourself and walk out.

The indoor shelters with which this pamphlet deals are unsuitable for houses with more than two storeys above the shelter room. They are intended chiefly for use in ordinary two-storey houses, but have a margin of strength that will take the weight of an extra storey.

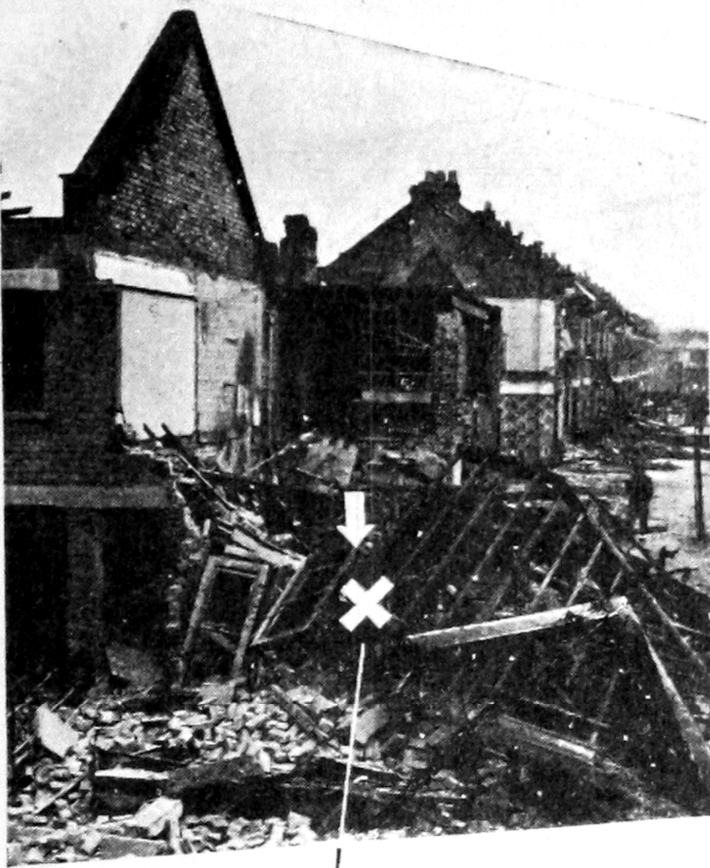
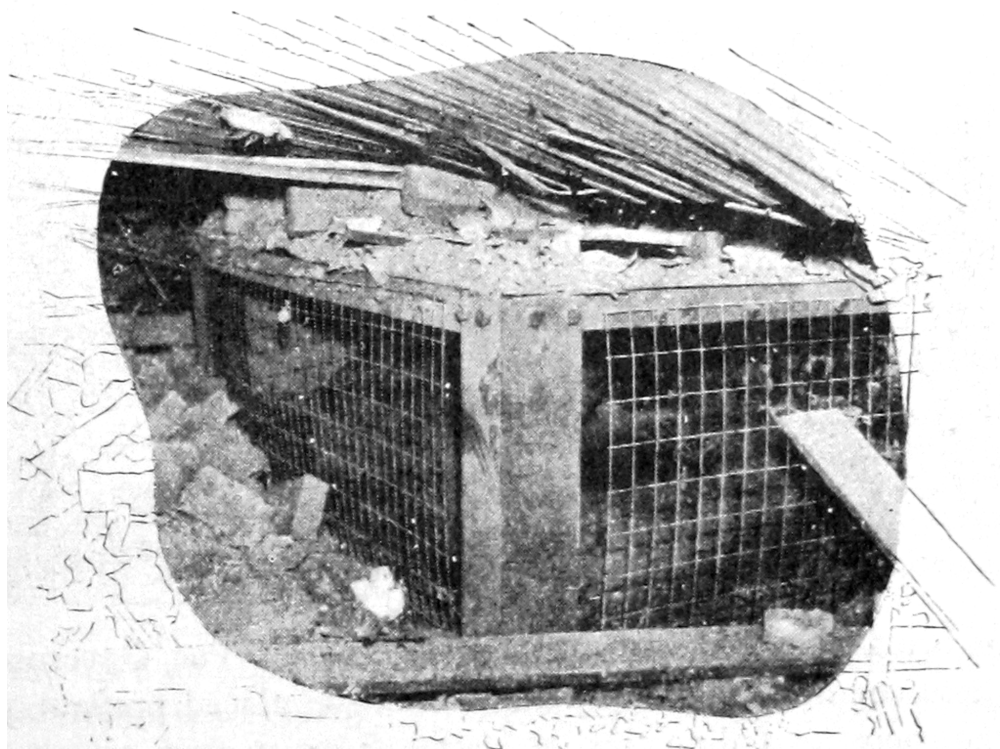


ILLUSTRATION NO. 8.

The house in the upper photograph had a Government steel table shelter in a downstairs room and was blown up to reproduce the effect of a heavy bomb falling near. The whole house collapsed, burying the shelter under débris. In the lower photo the shelter can be seen still intact. It would have been possible for anyone in the shelter to get out unaided.



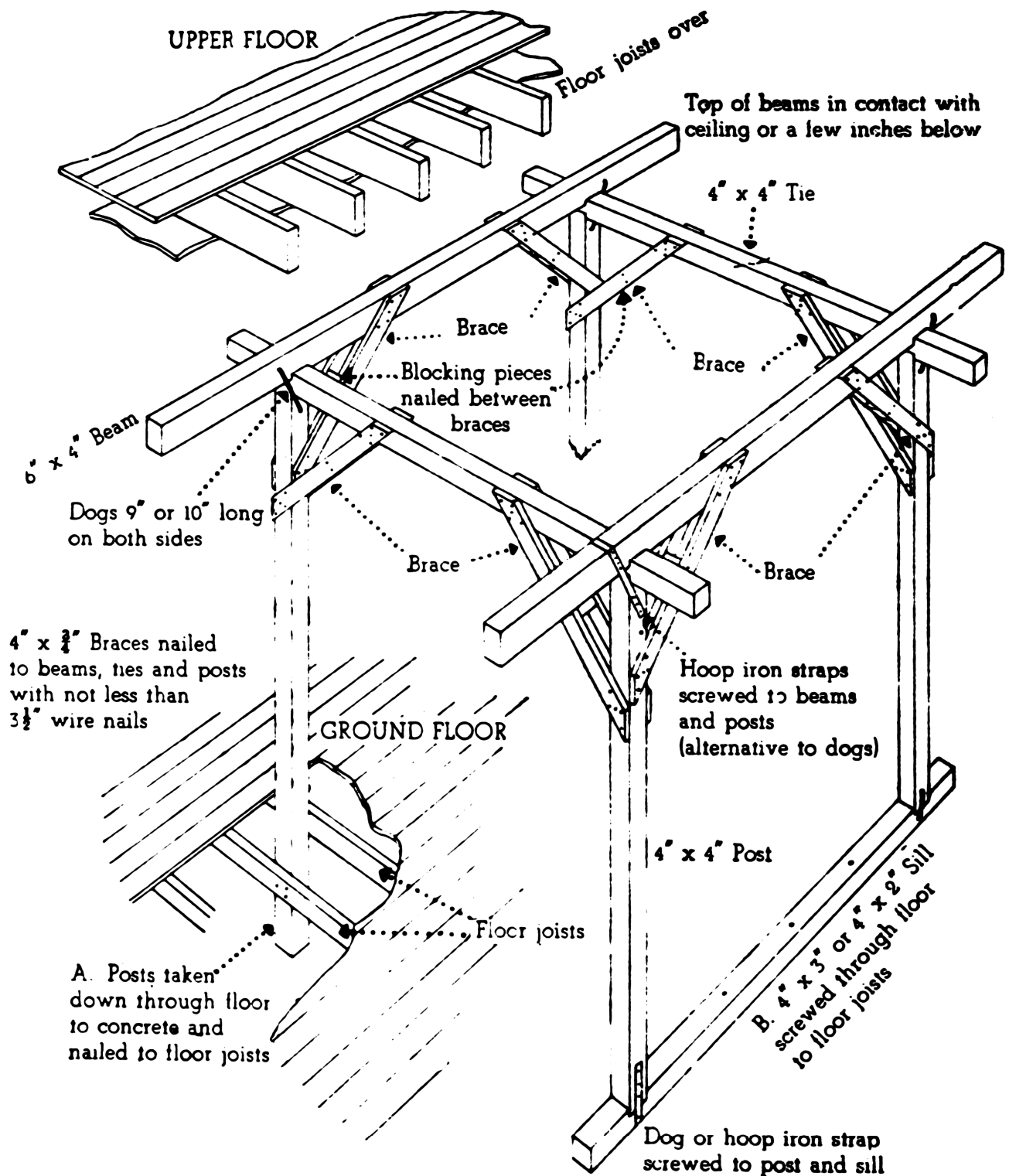


ILLUSTRATION NO. 11. Independent timber framework for a refuge room. If the posts are more than 6 ft. 6 in. apart, 8 in. $\times$ 4 in. beams are desirable.

A home-made shelter

You will have noticed earlier in this booklet the statement that people have often been rescued from demolished houses because they had taken shelter under an ordinary table. This was because the table had by chance been strong enough to bear the weight of the falling bedroom floor. A timber framework can be built inside a refuge room to do the same thing, but with certainty. ILLUSTRATION NO. 11 shows a completed framework

(THIS DOCUMENT IS THE PROPERTY OF HIS BRITANNIC MAJESTY'S GOVERNMENT).

SECRET.

W.P.(G)(41)7.

COPY NO. 62

January 15th, 1941.

W A R C A B I N E T.

AIR RAID SHELTER POLICY.

Memorandum by the Minister of Home Security.

6. Shelter in the home: The Anderson shelter was originally intended for indoor use but for a number of reasons including the danger of fire an outdoor variant was adopted. Experience has shown that the objections to the indoor use of the Anderson or somewhat similar shelter are not so serious as was thought and two designs have been produced which can be erected indoors without support. These new types, although they may give slightly less protection than a well covered Anderson shelter out of doors, would fill the needs of a large section of the public, especially the middle class. One design allows the use of the shelter as part of the furniture of the room.

7. I regard shelters of this type as of the first importance and wish to provide them on a big scale. Each shelter will use over 3 cwt. of steel and will allow at a pinch two adults and one to two children to sleep inside. For an outlay of about 65,000 tons of steel, as a first instalment, I could therefore produce 400,000 shelters with accommodation for at least 1,000,000 persons. I should wish to complete such a programme within the first three months of production and thereafter at a similar or increasing rate. From enquiries I believe that manufacture can be arranged provided steel is supplied and if the Cabinet approves my policy I shall require their direction that the steel be made available.

10. Conclusions.

I ask for a general endorsement of the policy I have outlined in this paper and in particular for the agreement of my colleagues:

- (i) that proposals for building shelters of massive construction should be rejected;
- (ii) that steel should be made available to carry out the programme outlined in paragraph 7 for the provision of steel shelters indoors;
- (iii) that the limit of income for the provision of free shelter for insured persons should be raised from £250 to £350 per annum.

H.M.

MINISTRY OF HOME SECURITY.

January 15th, 1941.

Morrison Shelters in Recent Air Raids.

National Archives
HO197/24

A report of Ministry of Home Security experts on 39 cases of bombing incidents in different parts of Britain covering all those for which full particulars are available in which Morrison shelters were involved shows how well they have stood up to severe tests of heavy bombing.

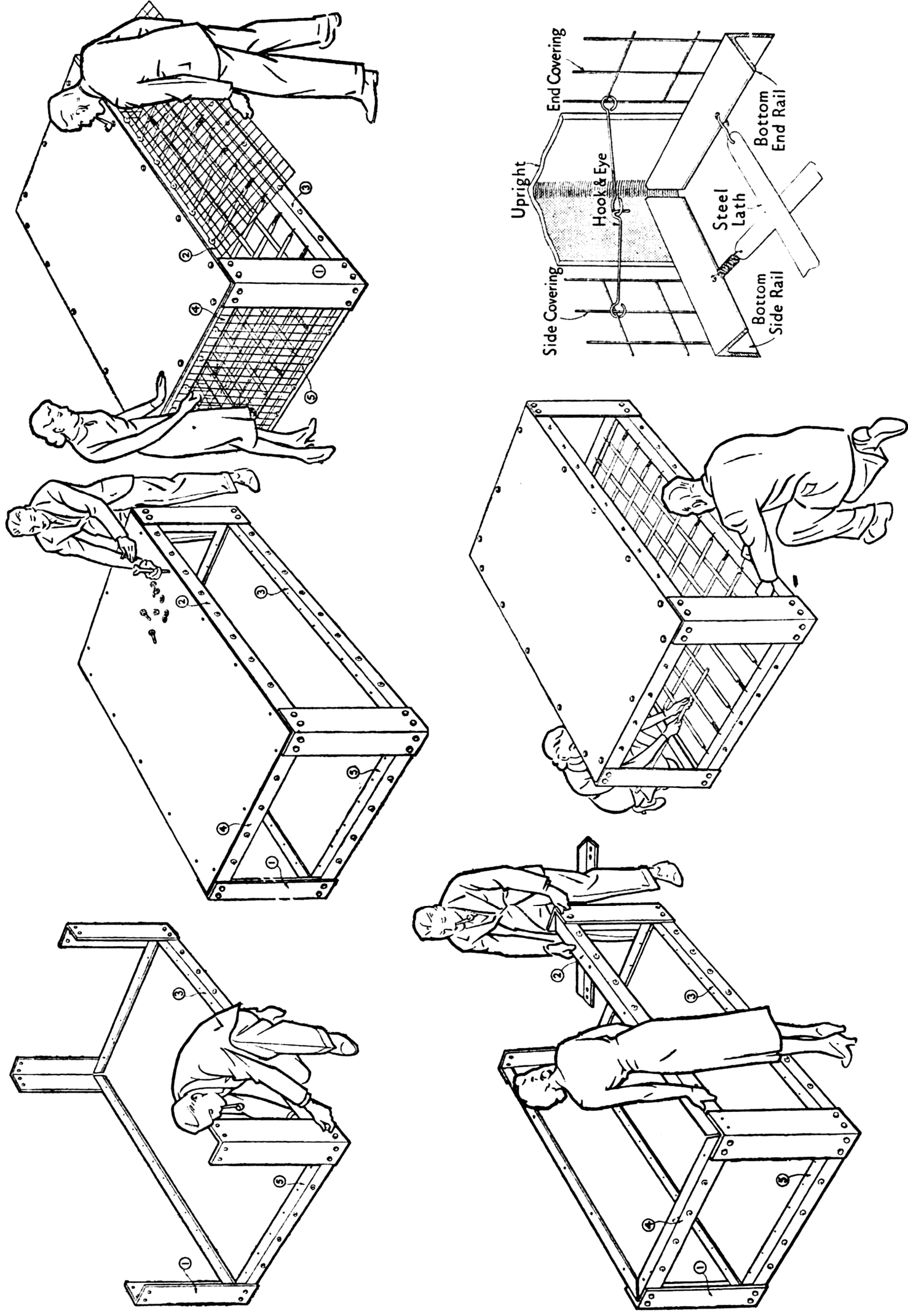
All the incidents were serious. Many of the incidents involved direct hits on the houses concerned a risk against which it was never claimed these shelters would afford protection. In all of them the houses in which shelters were placed were within the radius of damage by bombs; in 24 there was complete demolition of the house on the shelter.

A hundred and nineteen people were sheltering in these "Morrison" and only four were killed. So that 115 out of 119 people were saved. Of these only 7 were seriously injured and 14 slightly injured while 94 escaped uninjured. The majority were able to leave their shelters unaided.



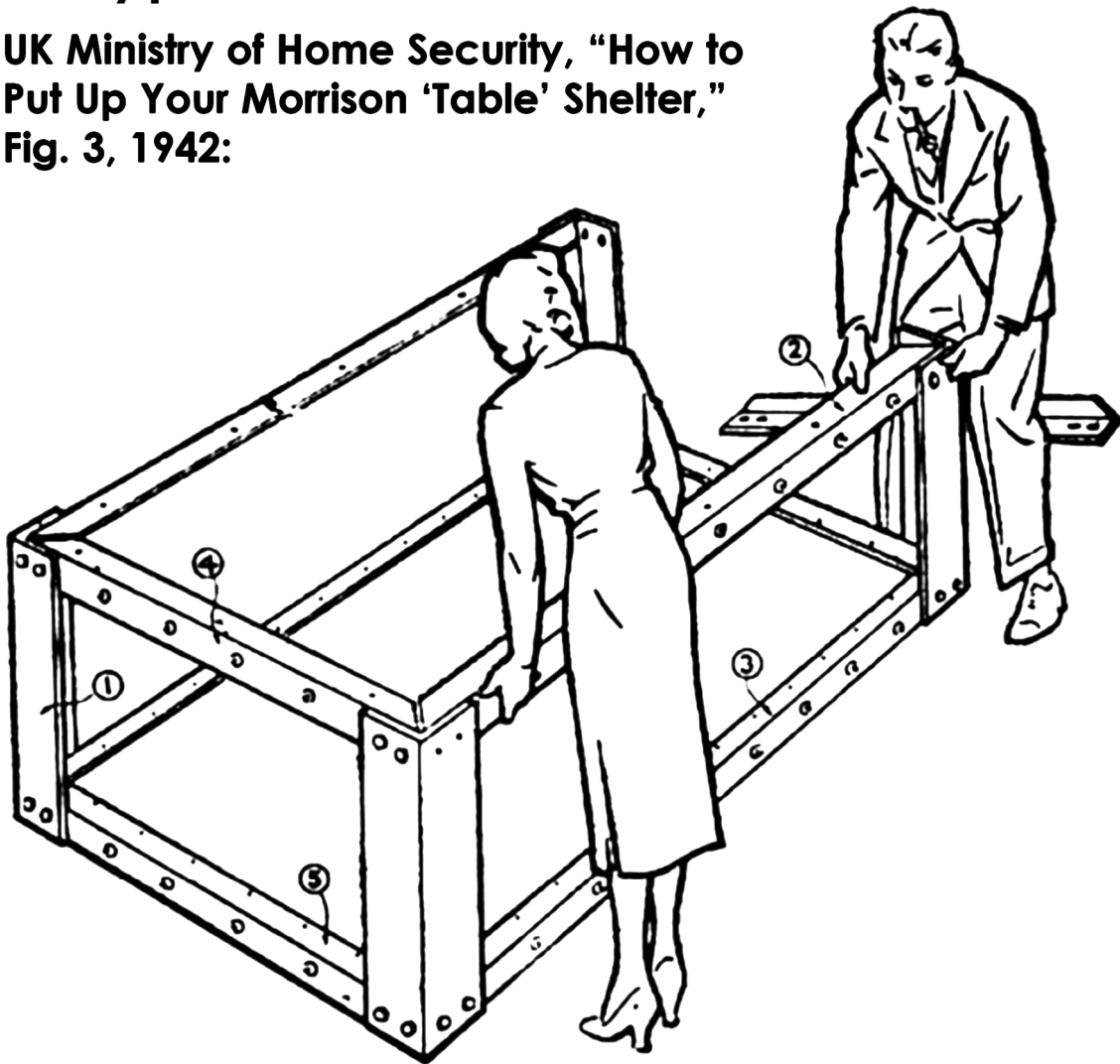
Structural Defense, 1945, by D. G. Christopherson, Ministry of Home Security, RC 450, (1946); Chapters VIII and IX (Confidential). National Archives
Chapter VIII summarizes the literature on the design and types of British shelters and analyzes their effectiveness. HO 195/16

How to Put Up Your "Morrison" Steel Table Shelter, 1942

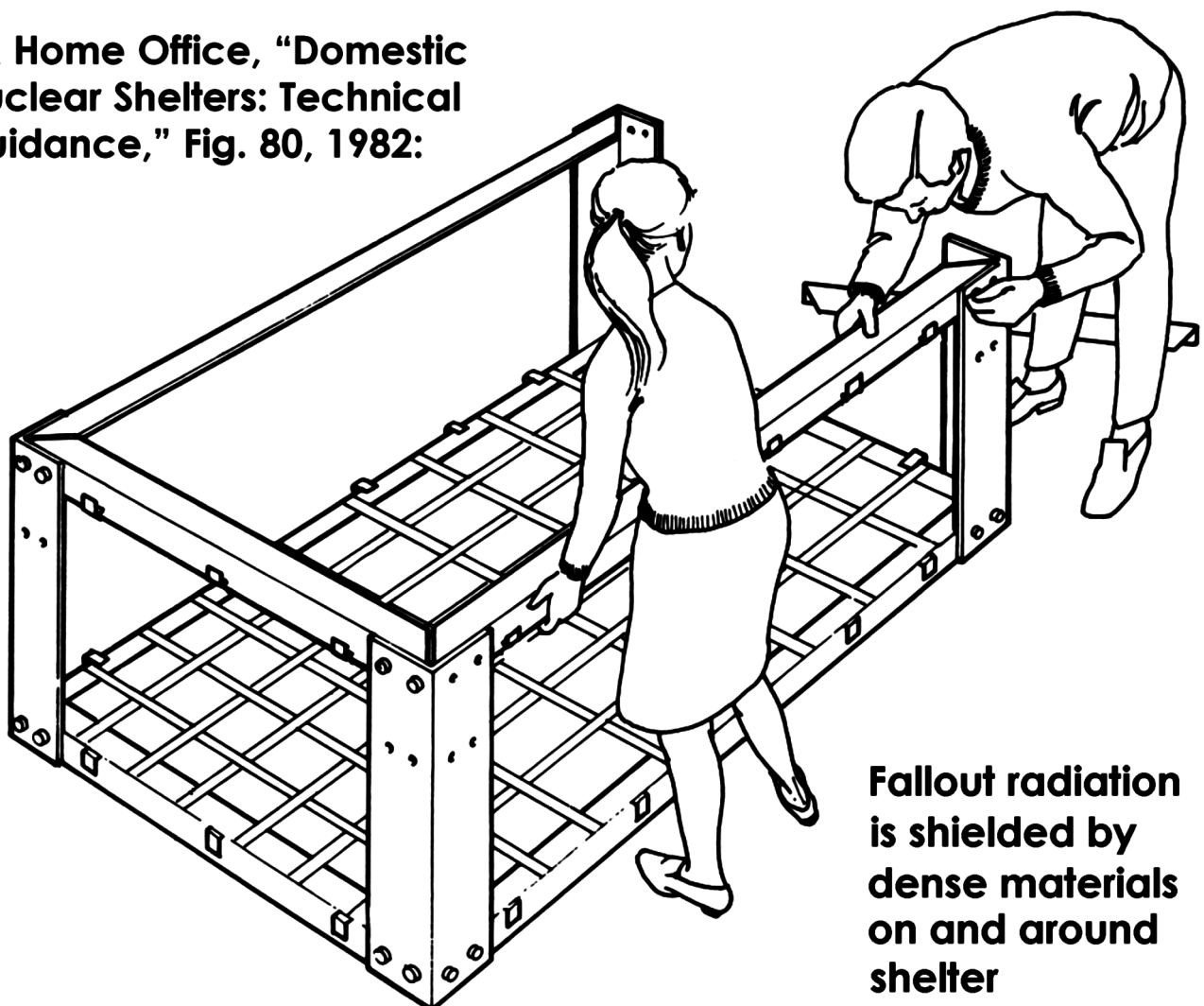


Type 2 indoor Morrison shelter

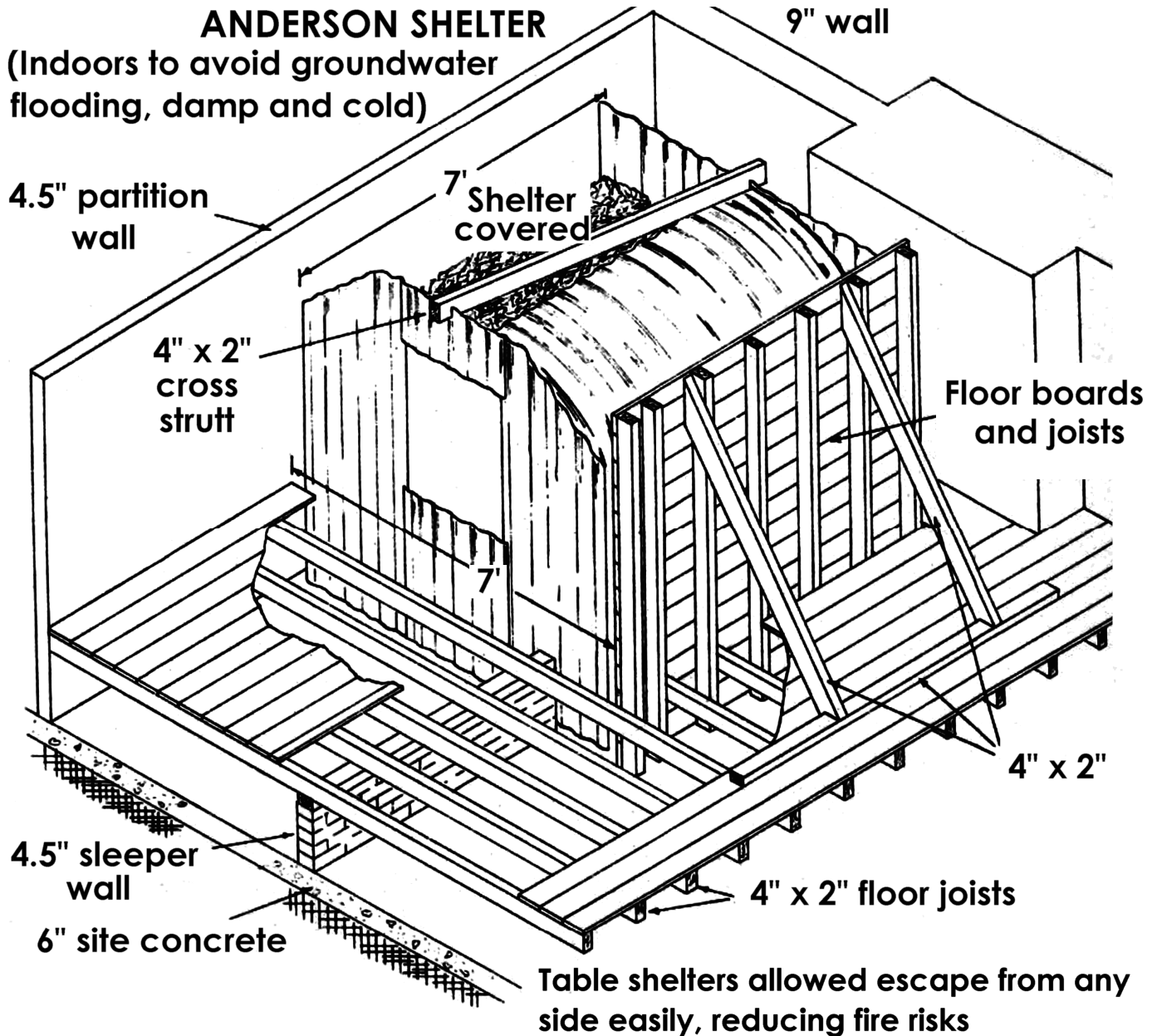
UK Ministry of Home Security, "How to Put Up Your Morrison 'Table' Shelter," Fig. 3, 1942:



UK Home Office, "Domestic Nuclear Shelters: Technical Guidance," Fig. 80, 1982:



Fallout radiation is shielded by dense materials on and around shelter



MORRISON SHELTER
(indoor table shelter)

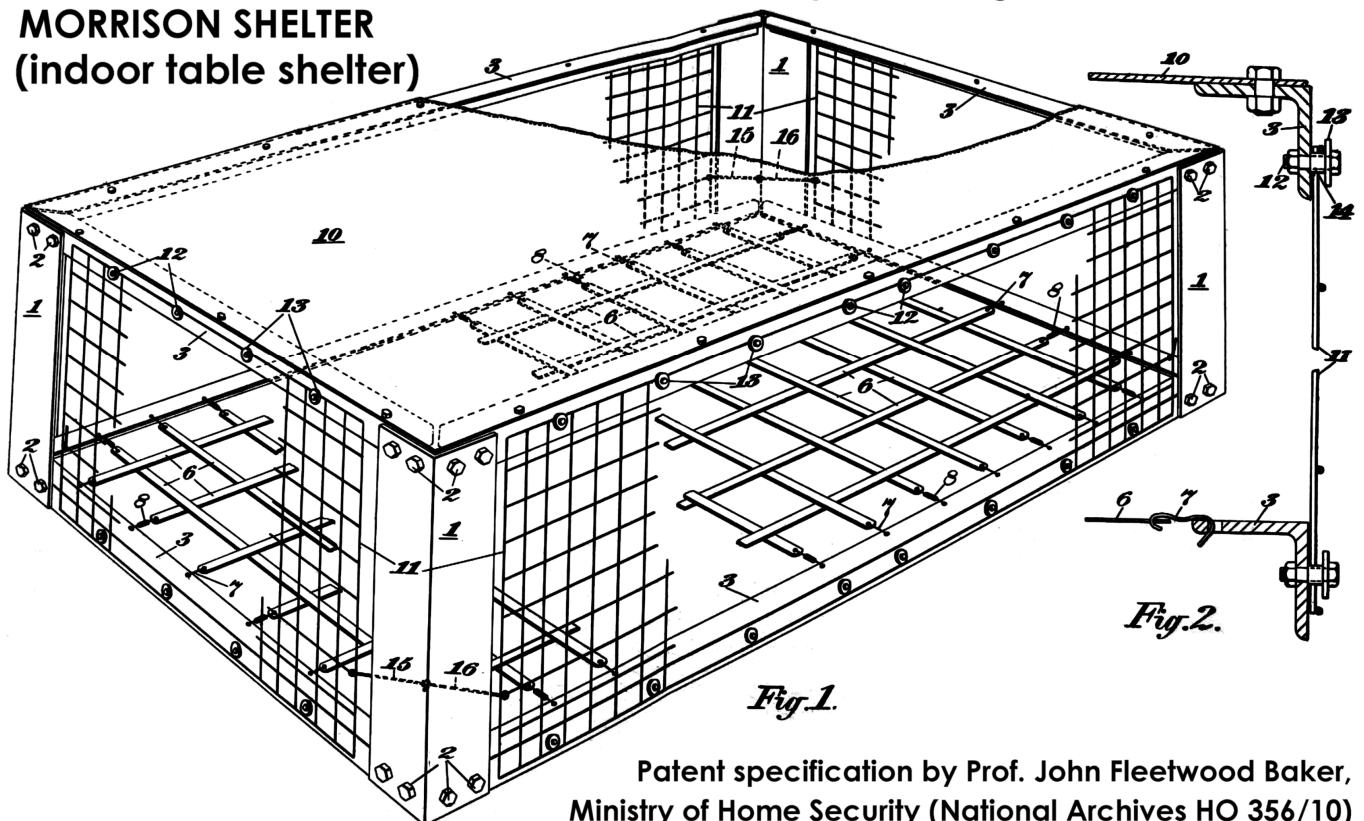




ILLUSTRATION NO. 8.

The house in the upper photograph had a Government steel table shelter in a downstairs room and was blown up to reproduce the effect of a heavy bomb falling near. The whole house collapsed, burying the shelter under débris. In the lower photo the shelter can be seen still intact. It would have been possible for anyone in the shelter to get out unaided.







Morrison shelter saves lives of Mr McGregor pictured beside Morrison shelter, as well as his wife and lodger, in collapsed house, York 1942 air raid



Morrison indoor table shelter test by Ministry of Home Security, 1941: result shelter survived and occupants would have escaped unaided. (Source: "Shelter at Home", June 1941 handbook.)



Morrison shelter saves lives of Mr McGregor (pictured beside Morrison shelter), as well as his wife and lodger, in collapsed house, York 1942 air raid

UK National Archives: HO 192/909

**Morrison shelter surviving 250 kg direct hit on 12 March 1943
on house at 10 Fore Street, Salcombe (Mrs Hannaford)**

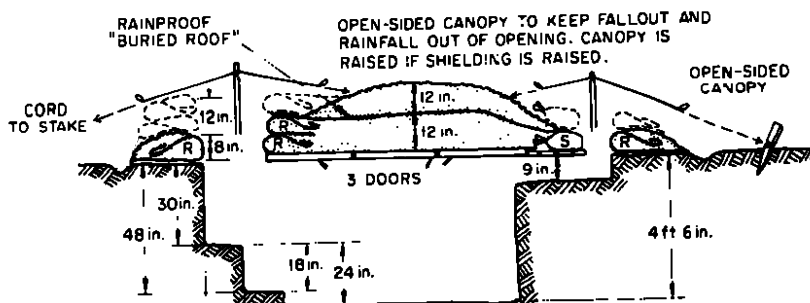
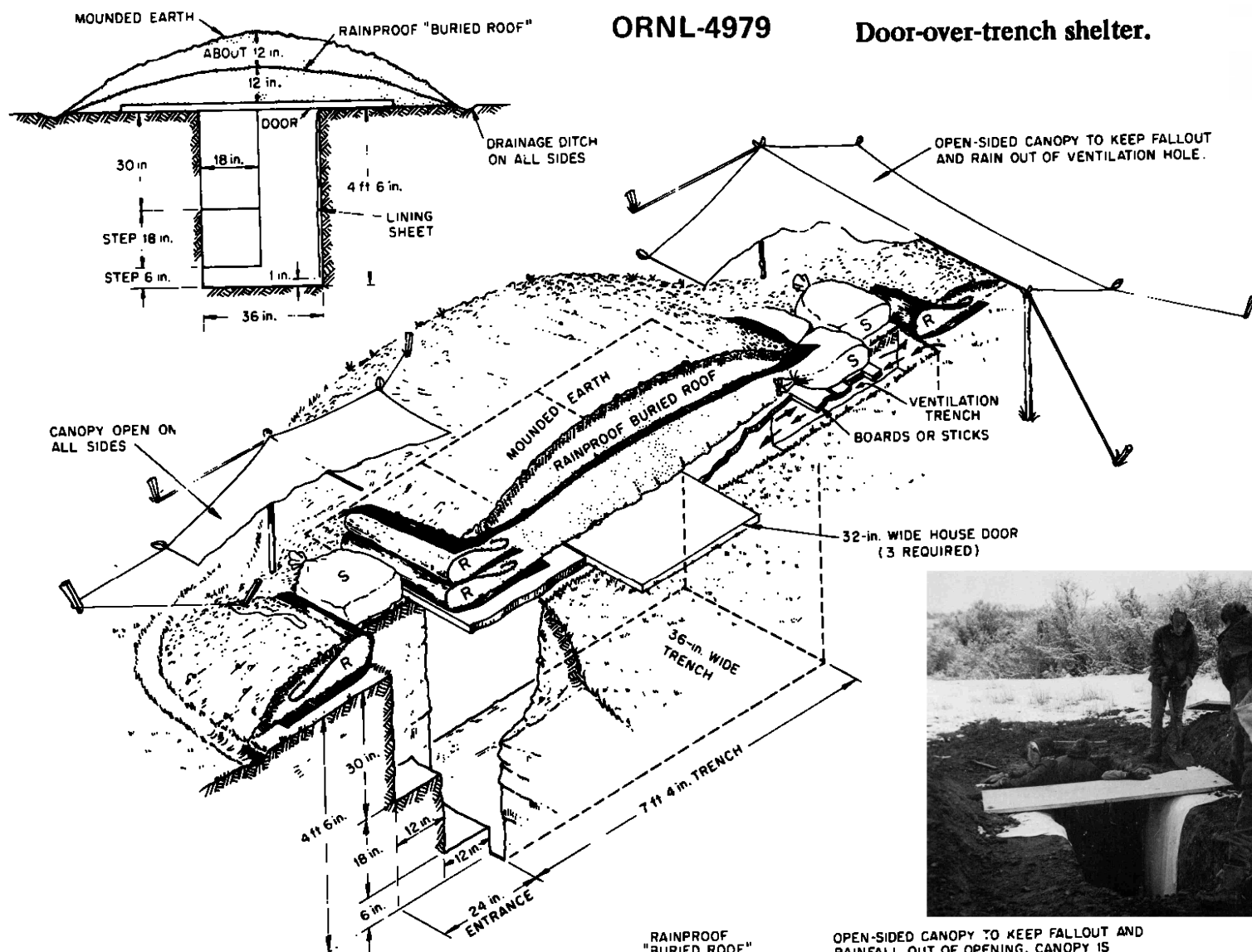




WWII Surface shelter (UK National Archives INF 13/218)

ORNL-4979

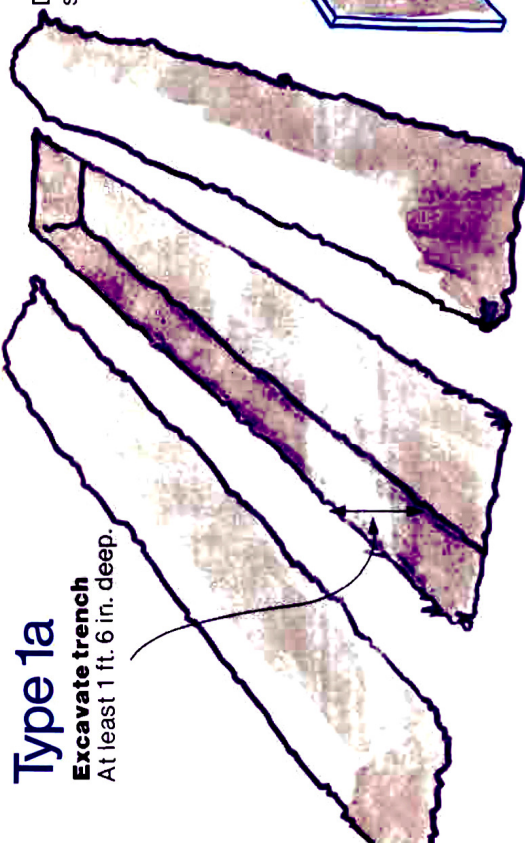
Door-over-trench shelter.



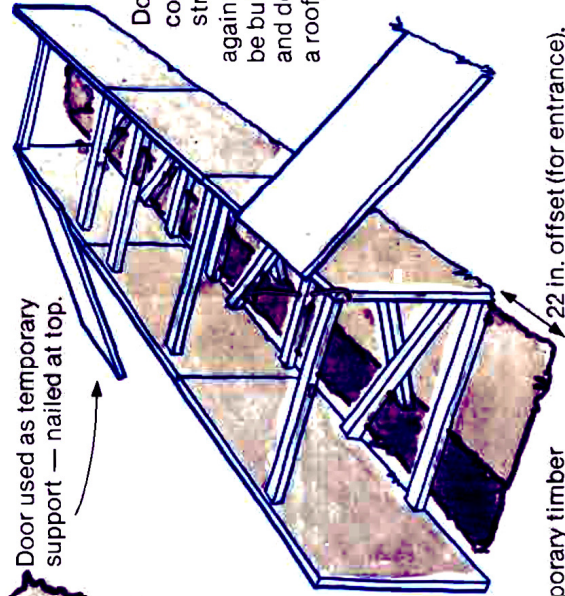
Type 1a

Excavate trench

At least 1 ft. 6 in. deep.



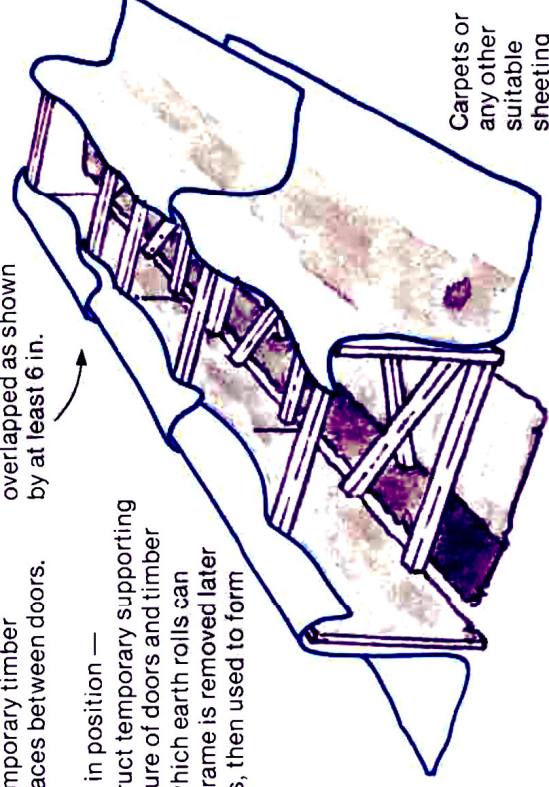
Spread spoil on both sides of trench, at least 2 ft. from the edge.



Door used as temporary support — nailed at top.

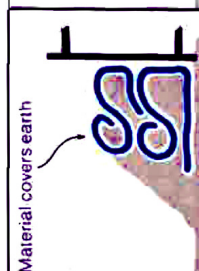
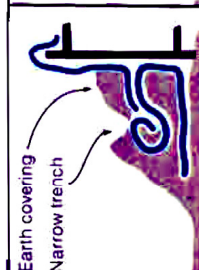
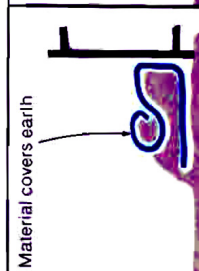
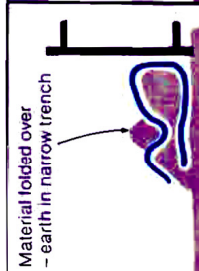
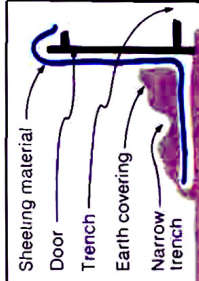
Doors in position — construct temporary supporting structure of doors and timber against which earth rolls can be built (frame is removed later and doors, then used to form a roof).

Material should be overlapped as shown by at least 6 in.

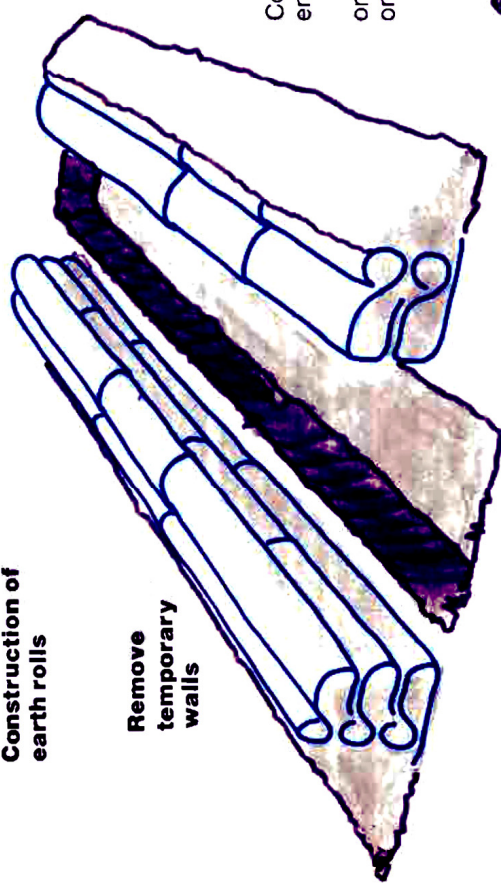


Carpets or any other suitable sheeting materials.

Construct temporary walls



Construction of earth rolls

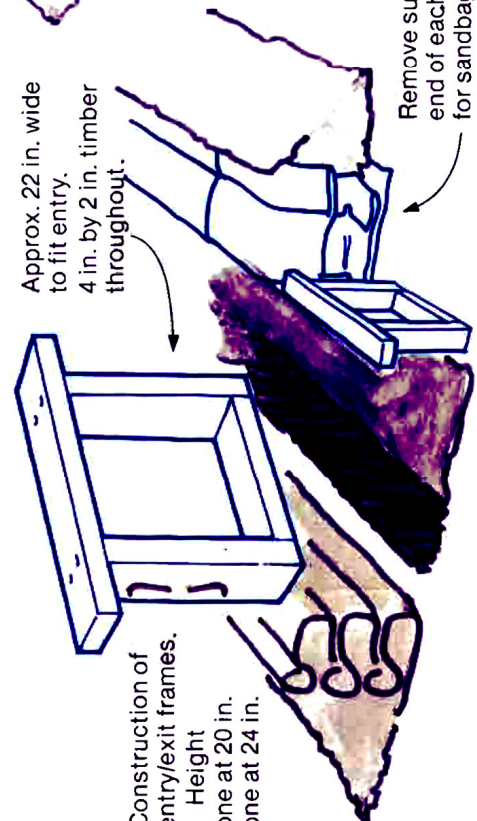


Remove temporary walls

Construct entry/exit frames

Approx. 22 in. wide to fit entry. 4 in. by 2 in. timber throughout.

Construction of entry/exit frames. Height one at 20 in. one at 24 in.



Two 10 in. high rolls (total height 20 in.).

Three 8 in. high rolls (total height 24 in.).

Sandbags will hold material in folded position.

Remove sufficient earth from end of each roll to allow space for sandbags. Fold material over to seal end.

Nuclear War Survival Skills

Cresson H. Kearny

[Note: Kearny was inspired to write this by the USSR manuals like "Antiradiation shelters in Urban Areas", 1972, English translation: Oak Ridge Nat. Lab., ORNL-TR-2745.]

**Oak Ridge National Laboratory
Oak Ridge, Tennessee**

September 1979

Summary

Underlying the advocacy of Americans' learning these down-to-earth survival skills is the belief that if one prepares for the worst, the worst is less likely to happen. Effective American civil defense preparations would reduce the probability of nuclear blackmail and war. Yet in our world of increasing dangers, it is significant that the United States spends much less per capita on civil defense than many other countries. The United States' annual funding is about 50 cents per capita, whereas Switzerland spends almost \$11 and, most importantly, the Soviet Union spends approximately \$20.

In the first chapter the myths and facts about the consequences of a massive nuclear attack are discussed. As devastating as such an attack would be, with adequate civil defense preparations and timely warning much of the population could survive.

- **Myth:** Fallout radiation from a nuclear war would poison the air and all parts of the environment. It would kill everyone. (This is the demoralizing message of *On the Beach* and many similar pseudo-scientific books and articles.)
- **Myth:** A heavy nuclear attack would set practically everything on fire, causing "firestorms"

These exaggerations have become demoralizing myths, believed by millions of Americans.



HIROSHIMA. Typical, part below ground, earth-covered, timber framed shelter 300 yds. from the centre of damage

One appendix of the handbook gives detailed, field-tested instructions for building six types of earth-covered expedient fallout shelters, with criteria to guide the choice of which shelter to build. The design features of several types of expedient blast shelters are described in another appendix. Two others contain instructions for making an efficient shelter-ventilating pump and a homemade fallout meter that is accurate and dependable. Both of these essentials can be made with inexpensive materials found in most households. Drawings are used extensively, as are photographs of people actually building and living in the various shelters.

This first-of-its-kind report is primarily a compilation and summary of civil defense measures and inventions developed at ORNL over the past 14 years and field-tested in six states, from Florida to Utah.

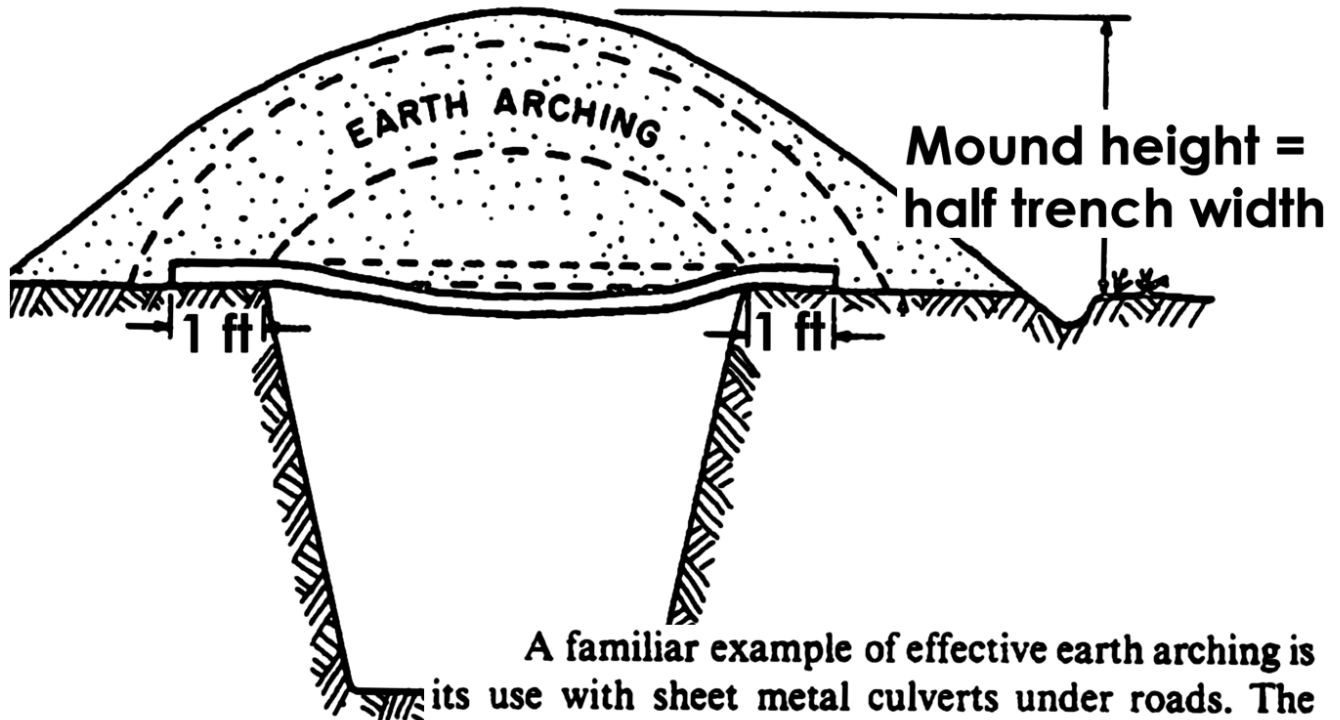
- **Myth:** In the worst-hit parts of Hiroshima and Nagasaki where all buildings were demolished, everyone was killed by blast, radiation, or fire.
- **Myth:** Because some modern H-bombs are over 1000 times as powerful as the A-bomb that destroyed most of Hiroshima, these H-bombs are 1000 times as deadly and destructive.



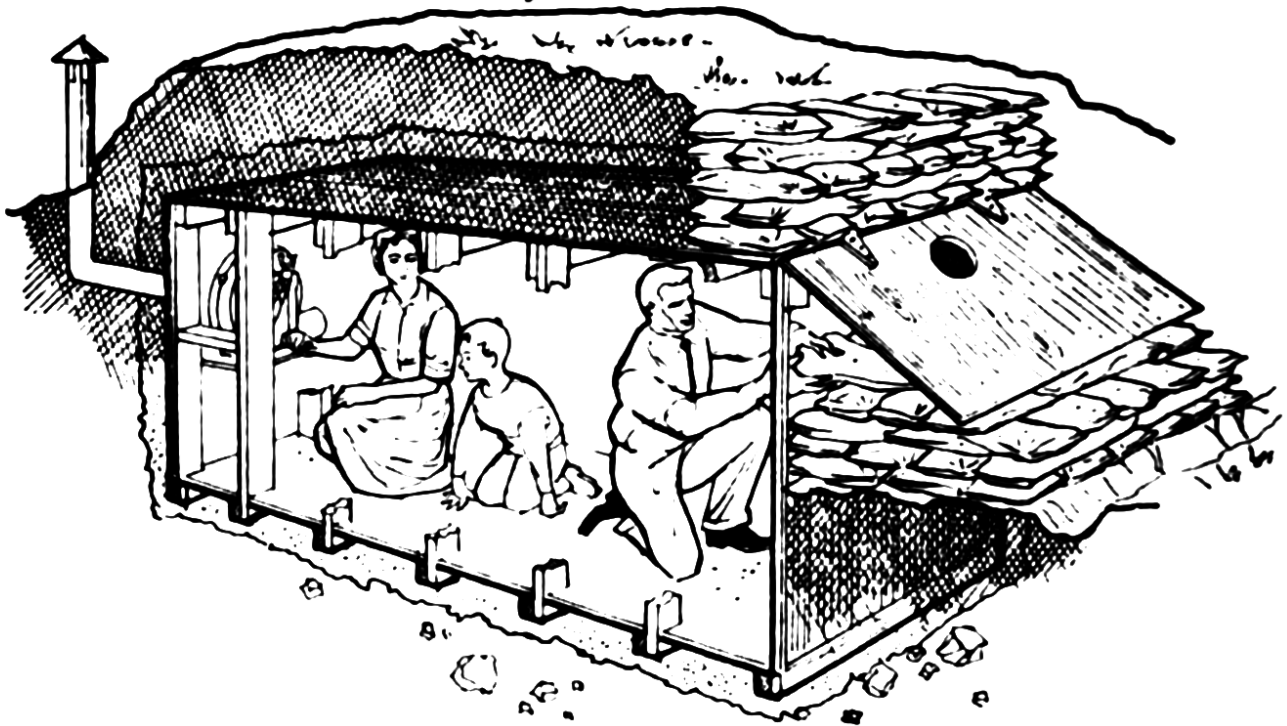
NAGASAKI. Typical small earth-covered back yard shelter with crude wooden frame, less than 100 yds. from the centre of damage

PREVENTION OF THYROID DAMAGE FROM RADIOACTIVE IODINES

An extremely small and inexpensive daily dose of the preferred non-radioactive potassium salt, potassium iodide (KI), if taken $\frac{1}{2}$ hour to 1 day before exposure to radioactive iodine, will reduce later absorption of radioactive iodine by the thyroid to only about 1% of what the absorption would be without this preventive measure. Extensive experimentation and study have led to the Federal Drug Administration's approval of 130-milligram (130-mg) tablets for this preventive (prophylactic) use only. A 130-mg dose provides the same daily amount of iodine as does each tablet that English authorities for years have placed in the hands of the police near nuclear power plants, for distribution to the surrounding population in the very unlikely event of a major nuclear accident. It is quite likely that a similar-sized dose is in the Russian "individual, standard first-aid packet." According to a comprehensive Soviet 1969 civil defense handbook, this first-aid packet contains "anti-radiation tablets and anti-vomiting tablets (potassium iodide and etaperain)."



A familiar example of effective earth arching is its use with sheet metal culverts under roads. The arching in a few feet of earth over a thin-walled culvert prevents it from being crushed by the weight of heavy vehicles.

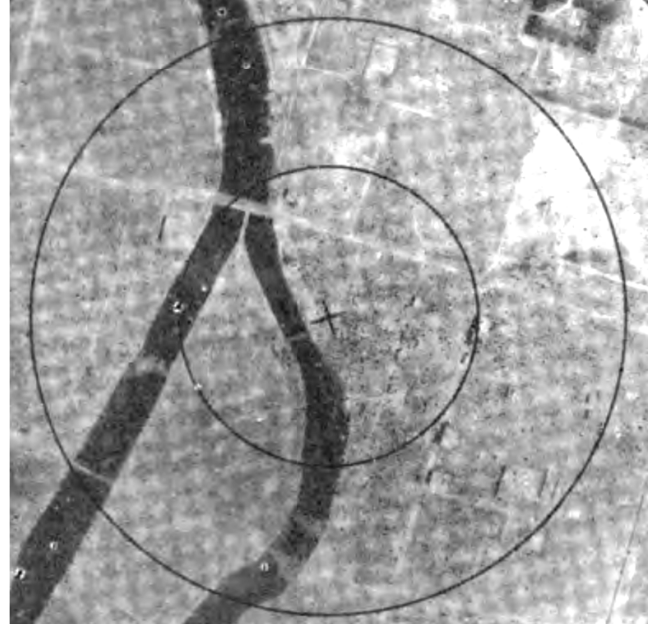


THE UNITED STATES STRATEGIC BOMBING SURVEY

THE EFFECTS OF ATOMIC BOMBS ON HIROSHIMA AND NAGASAKI

CHAIRMAN'S OFFICE

30 June 1946



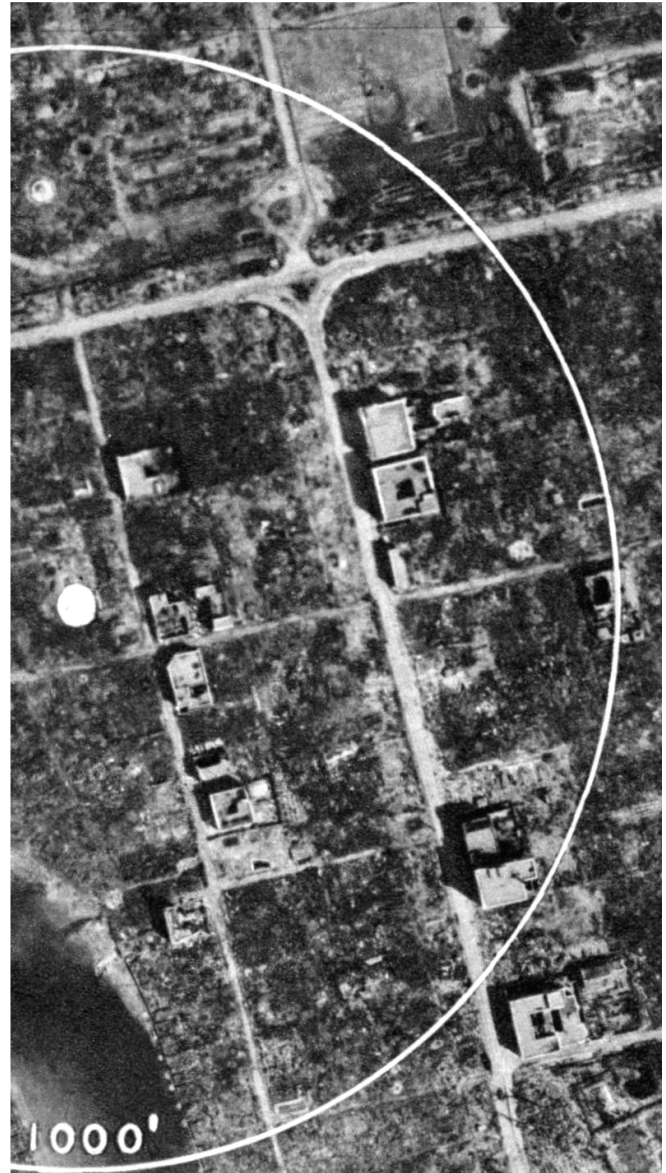
HIROSHIMA before and after bombing. Area around ground zero. 1,000 foot circles.

A. A. F. Photos

7

Above: surviving buildings are air-brushed out of photo of Hiroshima
1946 USSBS openly published Hiroshima and Nagasaki report, page 7

Below: secret BEFORE and AFTER Hiroshima photos



Hiroshima BEFORE (USSBS photo)

Modern concrete buildings AFTER.

Small wooden, overcrowded houses have burned down after
blast overturned stoves (8:15 am, breakfast time).

II. THE EFFECTS OF THE ATOMIC BOMBINGS

A. THE ATTACKS AND DAMAGE

1. *The attacks.*—A single atomic bomb, the first weapon of its type ever used against a target, exploded over the city of Hiroshima at 0815 on the morning of 6 August 1945. Most of the industrial workers had already reported to work, but many workers were enroute and nearly all the school children and some industrial employees were at work in the open on the program of building removal to provide firebreaks and disperse valuables to the country. The attack came 45 minutes after the "all clear" had been sounded from a previous alert. Because of the lack of warning and the populace's indifference to small groups of planes, the explosion came as an almost complete surprise, and the people had not taken shelter. Many were caught in the open, and most of the rest in flimsily constructed homes or commercial establishments.

At Nagasaki, 3 days later, the city was scarcely more prepared, though vague references to the Hiroshima disaster had appeared in the newspaper of 8 August. From the Nagasaki Prefectural Report on the bombing, something of the shock of the explosion can be inferred:

The day was clear with not very much wind—an ordinary midsummer's day. The strain of continuous air attack on the city's population and the severity of the summer had vitiated enthusiastic air raid precautions. Previously, a general alert had been sounded at 0748, with a raid alert at 0750; this was canceled at 0830, and the alertness of the people was dissipated by a great feeling of relief.

The city remained on the warning alert, but when two B-29's were again sighted coming in the raid signal was not given immediately; the bomb was dropped at 1102 and the raid signal was given a few minutes later, at 1109. Thus only about 400 people were in the city's tunnel shelters, which were adequate for about 30 percent of the population.

2. *Hiroshima.*

If there were, as seems probable, about 245,000 people in the city at the time of the attack, the density in the congested area must have been about 35,000 per square mile. Five completed evacuation programs and a sixth then in progress had reduced the population from its wartime peak of 380,000.

In Hiroshima (and in Nagasaki also) the dwellings were of wood construction; about one-half were one story and the remainder either one and one-half or two stories. The roof coverings were mostly hard-burnt black tile. There were no masonry division walls, and large groups of dwellings clustered together. The type of construction, coupled with antiquated fire-fighting equipment and inadequately trained personnel, afforded even in peacetime a high possibility of conflagration. Many wood-framed industrial buildings were of poor construction by American standards. The principal points of weakness were the extremely small tenons, the inadequate tension joints, and the inadequate or poorly designed lateral bracings. Reinforced concrete framed buildings showed a striking lack of uniformity in design and in quality of materials. Some of the construction details (reinforcing rod splices, for example) were often poor, and much of the concrete was definitely weak; thus some reinforced concrete buildings collapsed and suffered structural damage when within 2,000 feet of ground zero, and some internal wall paneling was demolished even up to 3,800 feet. (For convenience, the term "ground zero" will be used to designate the point on the ground directly beneath the point of detonation, or "air zero.")

Hiroshima's industrial production could have resumed normal operation within 30 days of the attack had the war continued.

official Japanese figures summed up the building destruction at 62,000 out of a total of 90,000 buildings in the urban area, or 69 percent. An additional 6,000 or 6.6 percent were severely damaged, and most of the others showed glass breakage or disturbance of roof tile. These figures show the magnitude of the problem facing the survivors.

Despite the absence of sanitation measures, no epidemics are reported to have broken out.

9

Nagasaki

Because parts of the city were protected by hills, more than one-half of the residential units escaped serious damage. Of the 52,000 residential units in the city on 1 August, 14,146 or 27.2 percent were completely destroyed (by Japanese count) (11,494 of these were burned); 5,441 or 10.5 percent were half-burned or destroyed; many of the remaining units suffered superficial or minor damage.

13

Because of the brief duration of the flash wave and the shielding effects of almost any objects—leaves and clothing as well as buildings—there were many interesting cases of protection. The radiant heat came in a direct line like light, so that the area burned corresponded to this directed exposure. Persons whose sides were toward the explosion often showed definite burns of both sides of the back while the hollow of the back escaped. People in buildings or houses were apparently burned only if directly exposed through the windows. The most striking instance was that of a man writing before a window. His hands were seriously burned but his exposed face and neck suffered only slight burns due to the angle of entry of the radiant heat through the window.

Flash burns were largely confined to exposed areas of the body, but on occasion would occur through varying thicknesses of clothing. Generally speaking, the thicker the clothing the more likely it was to give complete protection against flash burns.

17

A large percentage of the cases died of secondary disease, such as septic bronchopneumonia or tuberculosis, as a result of lowered resistance. Deaths from radiation began about a week after exposure and reached a peak in 3 to 4 weeks. They had practically ceased to occur after 7 to 8 weeks.

19

The flash heat was intense enough to cause fires, despite the distance of the fireball from the ground. Clothing ignited, though it could be quickly beaten out, telephone poles charred, thatched roofs of houses caught fire. In Hiroshima, the explosion started hundreds of fires almost simultaneously, the most distant of which was found 13,700 feet from ground zero; this, however, probably started when a building with a thatched roof collapsed onto a hot charcoal fire. Fires were started directly by flash heat in such easily ignitable substances as dark cloth, paper, or dry-rotted wood, within about 3,500 feet of ground zero; white-painted, concrete-faced or cement-stuccoed structures reflected the heat and did not ignite. A cedar bark roof and the top of a dry-rotted wooden platform 5,200 feet west of ground zero, were reported to have been ignited by the bomb flash. The majority of initial fires in buildings, however, were started by secondary sources (kitchen charcoal fires, electric short-circuits, industrial process fires, etc.).

Serious or third-degree burns were suffered by those directly exposed within 4,500 feet, and occasionally as remote as 7,200 feet. In the immediate area of ground zero, the heat charred corpses beyond recognition.

Clothing as well as buildings afforded considerable protection against the flash. Even a clump of grass or tree leaf was, on occasion, adequate.

The implication clearly is that the duration of the flash was less than the time required for the grass or leaf to shrivel. While an accurate estimate is not possible, the duration could hardly have exceeded a fraction of a second.

25



NEW SHOOTS are appearing on this limb of a chestnut tree, about 2,100 feet south of ground zero at Nagasaki, 2 months after the attack, even though the leaves were burned and withered at the time of the explosion (Japanese photo).

B. WHAT WE CAN DO ABOUT IT

The danger is real—of that, the Survey's findings leave no doubt. Scattered through those findings, at the same time, are the clues to the measures that can be taken to cut down potential losses of lives and property.

1. *Shelters.*—The most instructive fact at Nagasaki was the survival, even when near ground zero, of the few hundred people who were properly placed in the tunnel shelters. Carefully built shelters, though unoccupied, stood up well in both cities. Without question, shelters can protect those who get to them against anything but a direct hit. Adequate warning will assure that a maximum number get to shelters.

Analysis of the protection of survivors within a few hundred feet of ground zero shows that shielding is possible even against gamma rays. At Hiroshima, for example, persons in a concrete building 3,600 feet from ground zero showed no clinical effects from gamma radiation, but those protected only by wooden buildings at a similar distance suffered from radiation disease. The necessary thickness varies with the substance and with the distance from the point of detonation. Adequate shelters can be built which will reduce substantially the casualties from radiation.

Men arriving at Hiroshima and Nagasaki have been constantly impressed by the shells of reinforced concrete buildings still rising above the rubble of brick and stone or the ashes of wooden buildings. In most cases gutted by fire or stripped of partitions and interior trim, these buildings have a double lesson for us. They show, first, that it is possible without excessive expense to erect buildings which will satisfactorily protect their contents at distances of about 2,000 feet or more from a bomb of the types so far employed. Construction of such buildings would be similar to earthquake resistant construction, which California experience indicates would cost about 10 percent to 15 percent more than conventional construction. Even against more powerful bombs or against near misses, such construction would diminish damage.

As defensive weapons, atomic bombs are useful primarily as warnings, as threats of retaliation which will restrain a potential aggressor from their use as from the use of poison gas or biological warfare. The mission of active defense, as of passive defense, is thus to prevent the surprise use of the atomic bomb from being decisive. A wise military establishment will make sure—by dispersal, concealment, protection, and constant readiness of its forces—that no single blow or series of blows from an enemy can cripple its ability to strike back in the same way or to repel accompanying attacks from other air, ground, or sea forces. The measures to enable this unrelaxing state of readiness are not new; only their urgency is increased. Particularly is this true of the intelligence activities on which informed decisions and timely actions depend.

The need for research is not limited to atomic energy itself, but is equally important in propellants, detection devices, and other techniques of countering and of delivering atomic weapons.

5. *Conclusion.*—One further measure of safety must accompany the others. To avoid destruction, the surest way is to avoid war. This was the Survey's recommendation after viewing the rubble of German cities, and it holds equally true whether one remembers the ashes of Hiroshima or considers the vulnerability of American cities.

Our national policy has consistently had as one of its basic principles the maintenance of peace. Based on our ideals of justice and of peaceful development of our resources, this disinterested policy has been reinforced by our clear lack of anything to gain from war—even in victory. No more forceful arguments for peace and for the international machinery of peace than the sight of the devastation of Hiroshima and Nagasaki have ever been devised. As the developer and exploiter of this ominous weapon, our nation has a responsibility, which no American should shirk, to lead in establishing and implementing the international guarantees and controls which will prevent its future use.

Mechanix Illustrated, Jan. 1951

Head for the basement as soon as the siren sounds and remain as close as possible to heavy, supporting columns to avoid the danger of collapsing beams. Stay away from all entrances and all windows. If there are heavy steel doors and shutters, close them.

The British government recommends construction of raid shelters on the order of the Anderson-type, built outside many British homes during the Hitler blitz. These were steel arches, six feet high and four-and-a-half feet wide, half buried in the ground. Civil defense authorities assert that if three feet of earth were piled above the arch, the shelter could protect all inside from the four main causes of death and injury.

Don't be in a rush to emerge from your hideout—stay there until you have been assured the bomb will not be dropped, long enough for radiation outside to wear off.

IF YOU ARE TRAPPED ON THE TOP FLOOR OF A BUILDING . . .

and descent to the basement is prevented by jammed elevators and stairs, don't join the mob battling to get down. Proceed to a point as close to the center of the building as possible and lie against a wall or strong supporting column, out of line of the windows. Or crawl under a table, sofa or desk which would provide protection against flying glass.

IF YOU ARE WALKING ON THE STREET . . .

get out of the open. Remember that flash and flame burns killed 50 per cent of the 106,000 persons who died in the atomic attack on Hiroshima and Nagasaki and accounted for 75 per cent of all casualties. The bomb's heat rays travel in a straight line—so all you have to do is get inside.

Head for the nearest official shelter. If there aren't any, a subway—the deeper the better—will do as well.

Target area at Hiroshima was completely leveled except for a few reinforced concrete building frames. That's why American builders of A-bomb shelters concentrate on the use of thick concrete walls.

The U. S. Strategic Bombing Survey No. 5 undertaken by the U. S. Air Force, states flatly: "The most instructive fact at Nagasaki was the survival of the few hundred people who were properly placed in tunnel shelters. Without question, shelters can protect those who get to them against anything but a direct hit."

The best protection from shock, radiation and heat is reinforced concrete; almost as good is closely packed earth. The thickness required to protect you fully depends, obviously, on the distance from the blast. How much protection and at what distances? Well many other factors influence the effect of an atomic blast, including height of the burst, direction of the blast and types of buildings in its path. The government handbook, *The Effects of Atomic Weapons*, estimates that at a half-mile from the explosion, a 12-inch reinforced concrete wall inside a building would provide enough protection.





Anderson shelter destroyed by absorbing the blast
in 1940 London protected five shelterers from injury

DISASTER AND RECOVERY: A HISTORICAL SURVEY

Jack Hirshleifer

MEMORANDUM

RM-3079-PR

AD 403337

1963

The RAND Corporation
SANTA MONICA • CALIFORNIA

-12-

As at Hamburg, people proved tougher than structures. Almost 70 per cent of the buildings in Hiroshima were destroyed, compared with around 30 per cent of population.¹

The Research Department of the Hiroshima Municipal Office is reported to have estimated the population in the city as 407,000, in Hiroshima (Hiroshima Publishing Company, 1949).

¹These proportions are the estimates used by the U.S. Strategic Bombing Survey report. The Hiroshima Municipal Office calculations show an even greater disparity, reporting 22 per cent of population killed and missing but some 89 per cent of buildings as destroyed or needing reconstruction (Hiroshima).

-13-

On August 7 power was generally restored to surviving areas, and through railroad service commenced on August 8. Telephone service started on August 15. Hiroshima was also not a dead city. The U.S. Strategic Bombing Survey reported that plants responsible for three-fourths of the city's industrial production could have resumed normal operations within 30 days (the newer and larger plants in Hiroshima were on the outskirts of the city, and both physical premises and personnel generally survived).¹ By mid-1949 the population had grown to over 300,000 once more, and 70 per cent of the destroyed buildings had been reconstructed.²

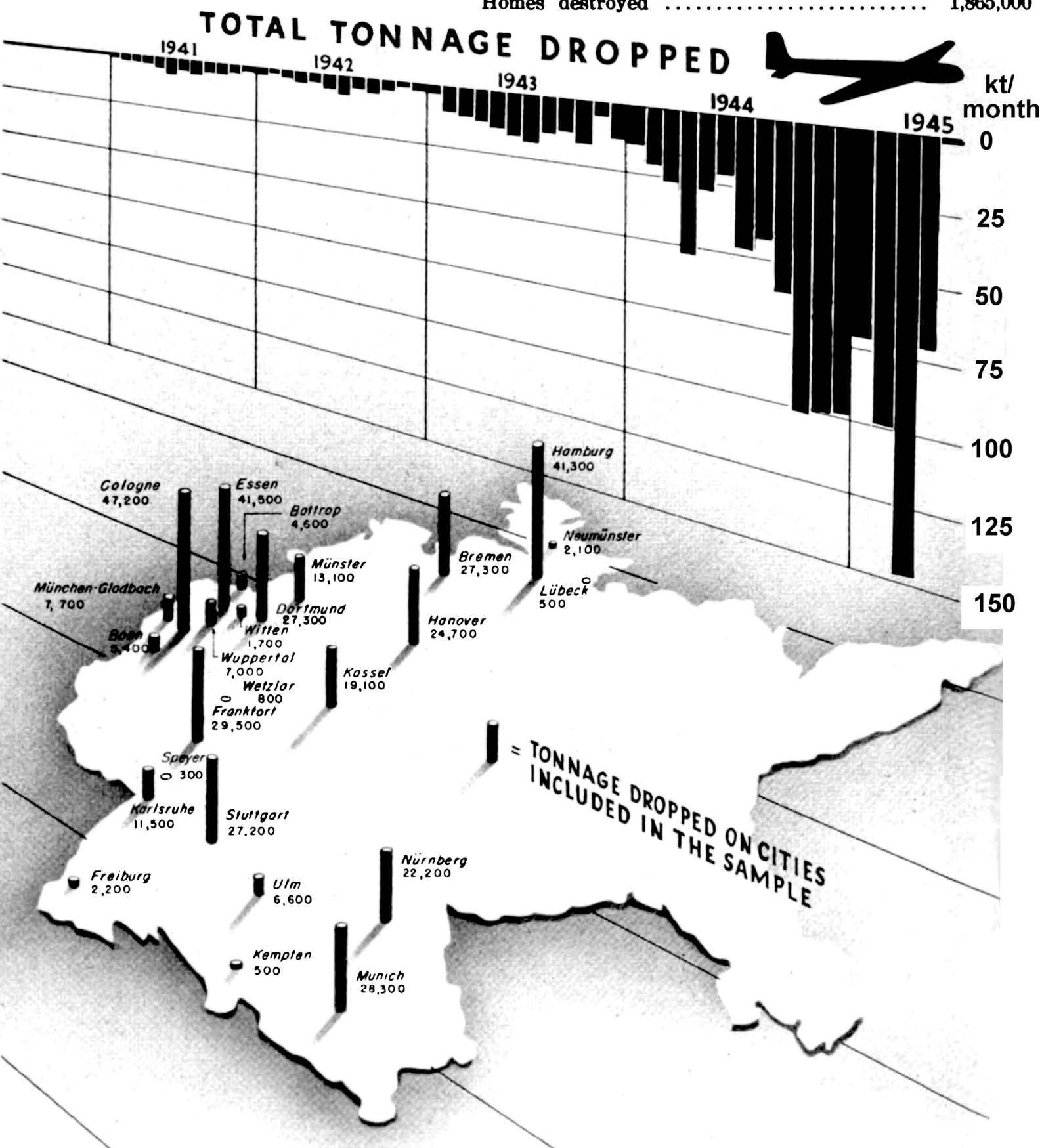
¹USSBS, "The Effects of Atomic Bombs at Hiroshima and Nagasaki," p. 8.

²Hiroshima.

BOMBING ATTACKS ON GERMANY

TABLE 1.—Physical effects of bombing

Killed	305,000
Wounded	780,000
Homes destroyed	1,865,000



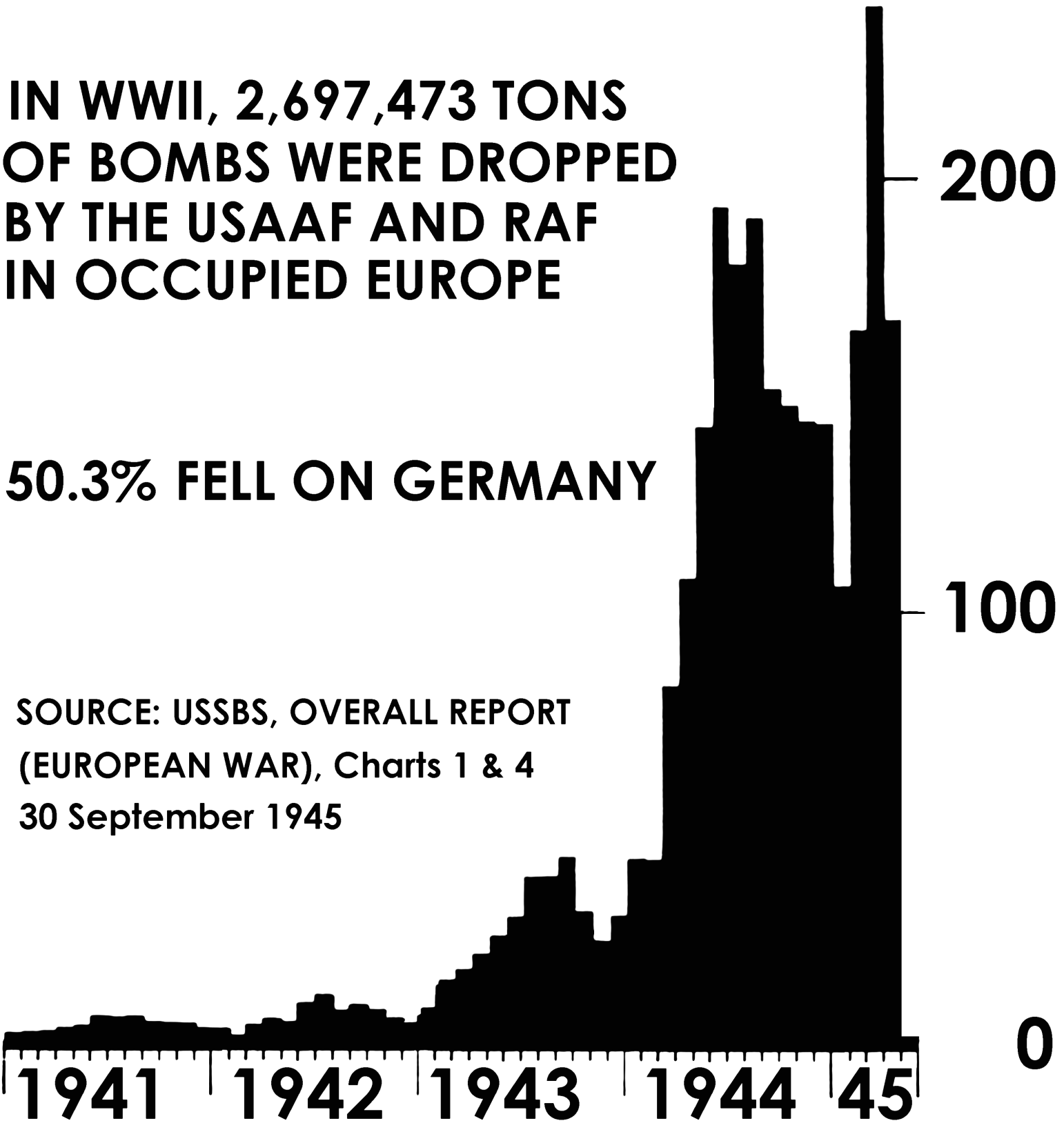
Source: U.S. Strategic Bombing Survey, "The Effects of Strategic Bombing on German Morale, Volume 1", May 1947.

CONVENTIONAL KILOTONS/MONTH DROPPED IN WWII BY ALLIES

IN WWII, 2,697,473 TONS
OF BOMBS WERE DROPPED
BY THE USAAF AND RAF
IN OCCUPIED EUROPE

50.3% FELL ON GERMANY

SOURCE: USSBS, OVERALL REPORT
(EUROPEAN WAR), Charts 1 & 4
30 September 1945



Over-all Report (European War). 109 pp. STRATEGIC BOMBING SURVEY

This volume recounts the history of the build-up of air power, showing the great increase in 1945. The results of attack on selected major industries in Germany are also considered. The report concludes that attrition caused the downfall of economy, especially as it affected transportation and oil.

LOGISTICS TARGETTED

Summary Report (European War). 18 pp. STRATEGIC BOMBING SURVEY

Germany planned a quick war; the Allies planned a long war and started a systematic attack on German industry. The British concentrated on area raids; the United States, on precision bombing. Ball bearings, aircraft, oil, steel, and transportation were attacked in order. The attack on transportation was the decisive blow that completely disorganized the German economy. Civilians withstood bombing fairly well, and the recuperation of German industry was surprising.

CIVIL DEFENCE

RESCUE MANUAL

LONDON

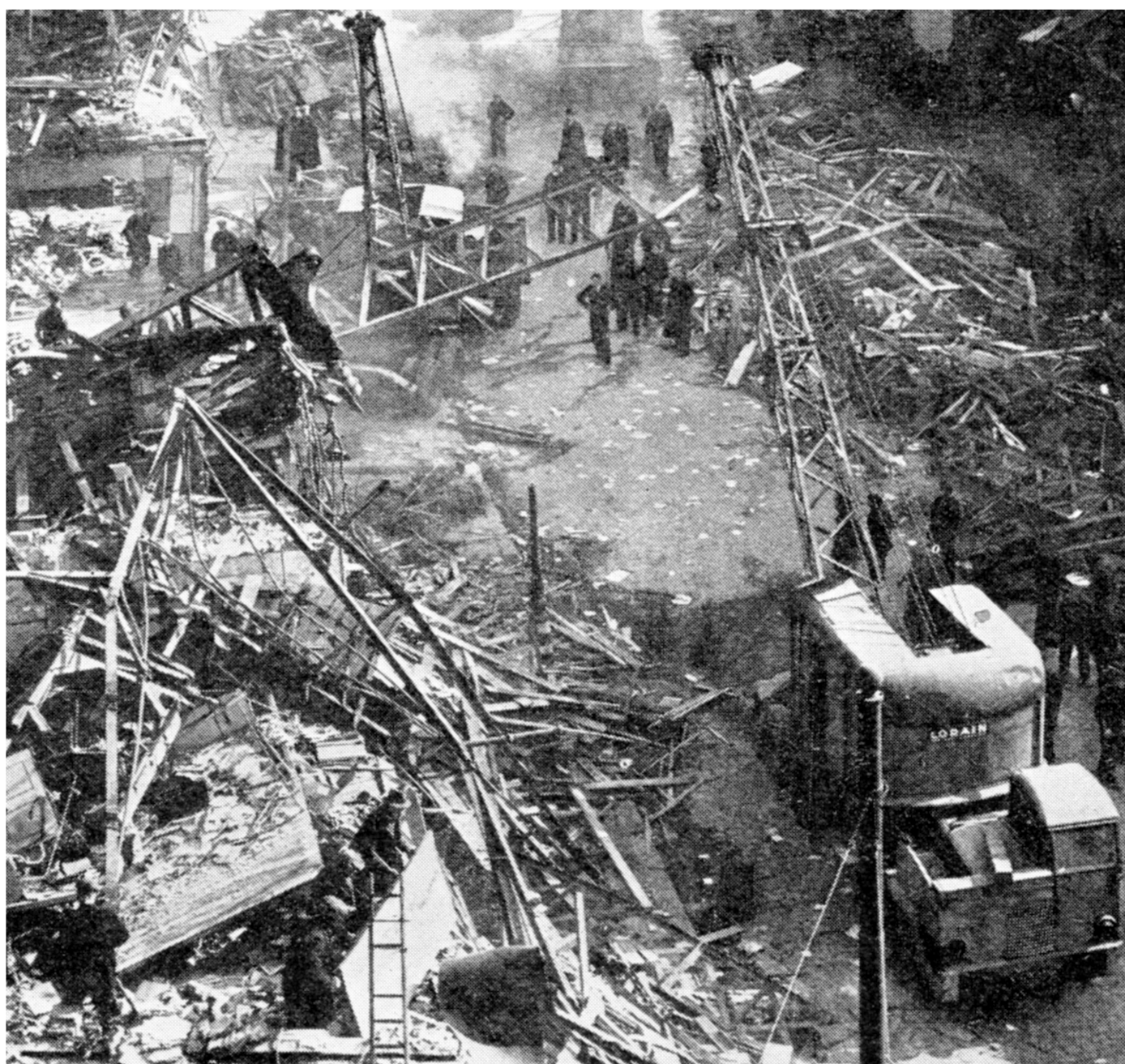
HER MAJESTY'S STATIONERY OFFICE

1952

CHAPTER XI. USE OF HEAVY MECHANICAL PLANT IN RESCUE, DEMOLITION AND CLEARANCE OPERATIONS

In the last war it was found that at major incidents the use of heavy mechanical plant was frequently necessary in support of rescue operations. Such equipment was used to help in the quick removal of debris ; to lift heavy blocks of brickwork or masonry ; to take the weight of collapsed floors and girders so that voids could be explored and casualties extricated ; to haul off twisted steelwork and other debris and to break up sections of reinforced concrete.

In future all these tasks may be required and heavy clearance may have to be effected to enable rescue and other Civil Defence vehicles



8 March 1945

Fig. 20 1 ton of TNT equivalent

Using heavy mechanical plant at the Smithfield Market V.2 incident.

to approach within measurable distance of their tasks. The problem of debris will in fact be a major factor in Civil Defence operations.

Heavy mechanical plant may be required for the following purposes :

- (a) To assist in the removal of persons injured or trapped. At this stage mainly heavy plant is needed, particularly mobile cranes with sufficient length of boom or jib to reach for long distances over the wreckage of buildings.
- (b) To force a passage for Civil Defence vehicles and fire appliances to enable them to reach areas where major rescue and other problems exist and require urgent operational action.
- (c) To take certain safety measures—e.g., to pull down unsafe structures.
- (d) To clear streets and pavements to help restore communications and to afford access for the repair of damaged mains and pipes beneath the streets.
- (e) For the final clearance of debris and the tidying of sites. This is a long term and not an operational requirement.

Urgent Rescue Operations

During rescue operations in London in the last war the machines used with great success included heavy $3\frac{1}{2}$ -5 ton mobile cranes, mounted on road wheels, with a 30-40 ft. jib ; medium heavy 2- $3\frac{1}{2}$ ton mobile cranes, mounted on road wheels, with a 26 ft. jib ; heavy crawler tractor bulldozers ; medium crawler tractor bulldozers ; mechanical shovels and compressors, three stage, mounted on road wheels.

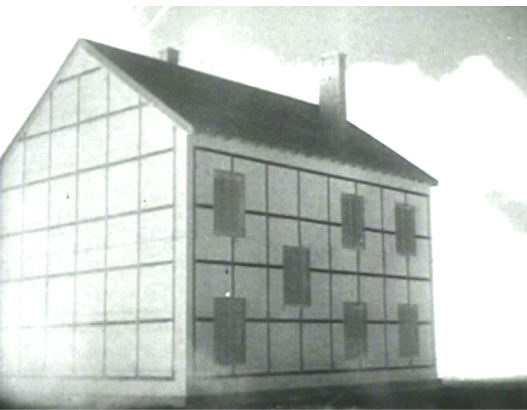
In the case of a large or multiple incident where access was obstructed by considerable quantities of scattered debris, a bulldozer or tractor was first employed in order to clear one or more approaches by which other equipment and personnel could reach the scene of operations.

Next, all debris of manhandling size was loaded into one-yard skips and discharged by the crane into lorries, giving increased manœuvring space to the Services operating on the site.

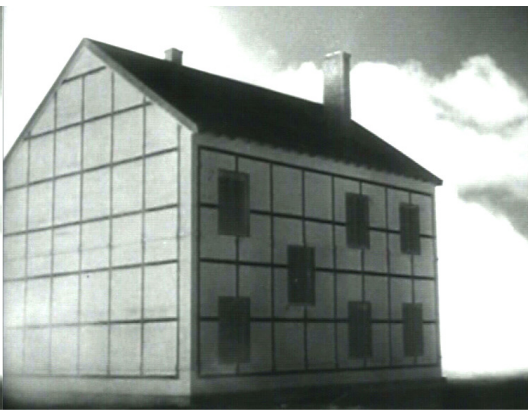
Heavy mobile cranes were then brought up to the incident where, used under the skilled direction of the rescue party Leader, they were invaluable for removing girders and large blocks of masonry which obstructed access to casualties or persons trapped. The necessary chains and wire ropes for these operations formed part of the standard equipment of the heavy and medium-heavy mobile cranes.

The work was, of course, carried out in close co-operation with the Rescue Parties who also used various forms of light mechanical equipment, such as jacks and ratchet lifting tackle for work in confined spaces.

Compressors sometimes proved valuable for breaking up large masonry such as fallen walls, into sections of a size and weight within the handling and lifting capacity of the cranes. This method was only used when it was known that there were no casualties under the masonry.



Detonation time



0.4 second



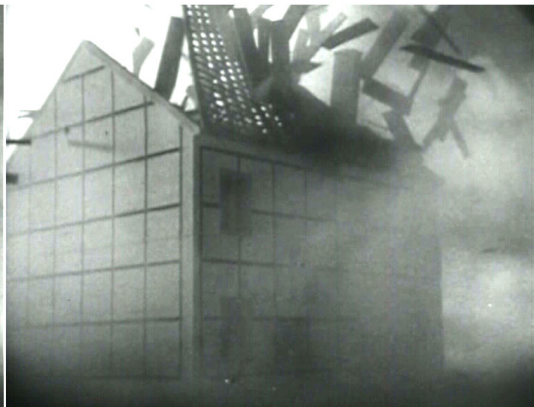
0.5 second: blast blows up roof



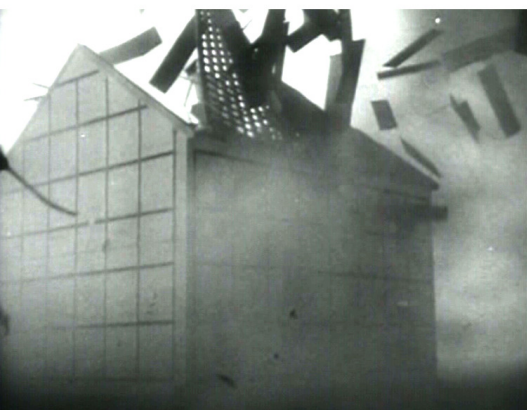
0.7 second: roof panels blow off



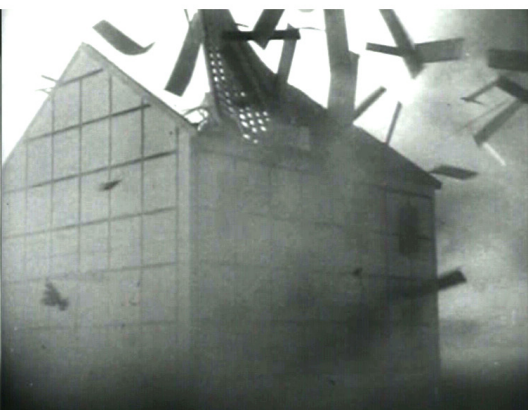
0.8 second



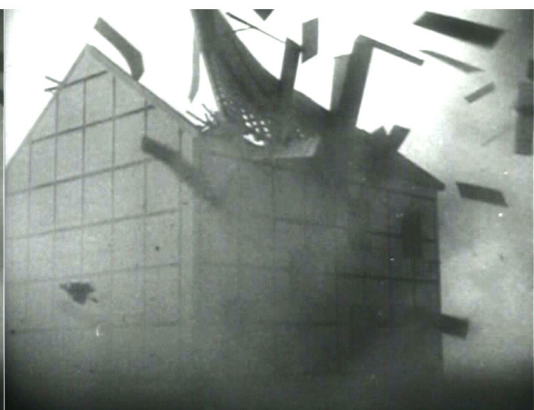
1.1 second



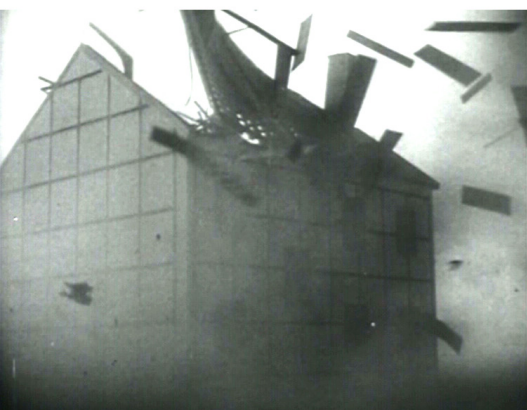
1.3 second



1.5 second



1.6 second



1.7 second



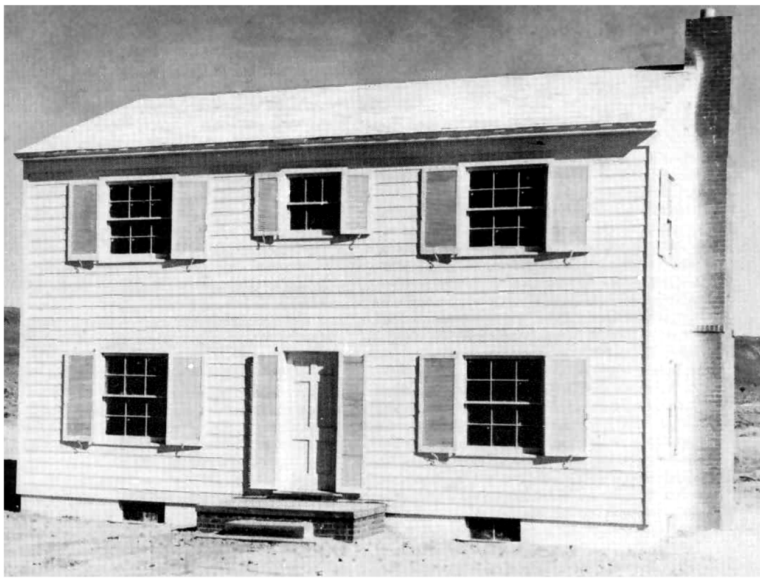
2.0 second



2.1 second

**47 kt EASY nuclear test at Eniwetok Atoll in 1951,
exposing a brick house to 3 psi peak overpressure.**

**Walls withstood blast although light roof panels
were blown off. Repair cost = 10% of rebuild cost.**



1 HB-8

The house at Main and Elm Streets. Two typical colonial two-story center hall frame dwellings were placed at 3,500 and 7,500 feet from the bomb tower. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)



X-19

This mannequin can only stay in the position in which he was placed, staring through the window at coming disaster. A real occupant of this house could prepare—and survive. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)

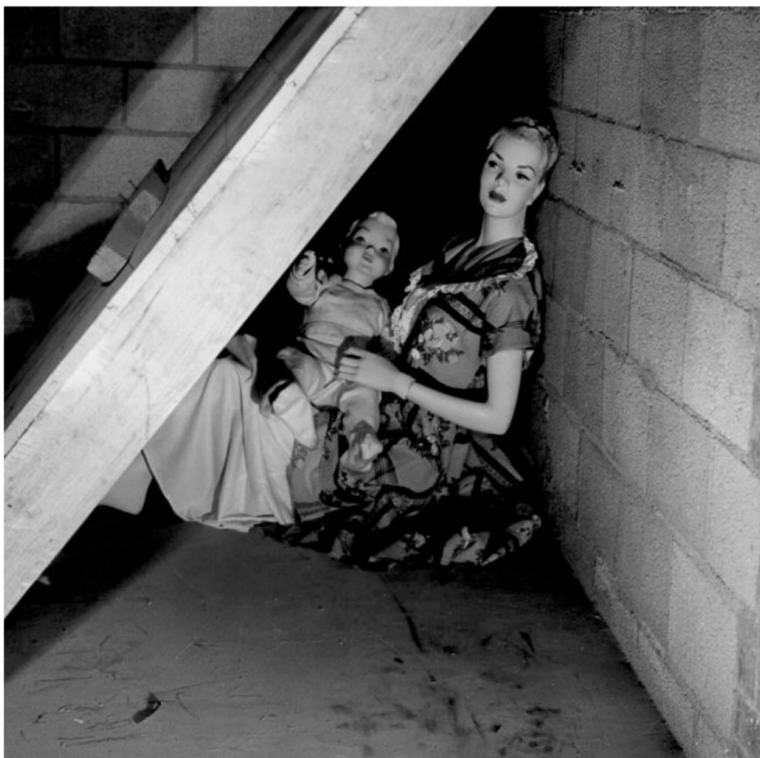


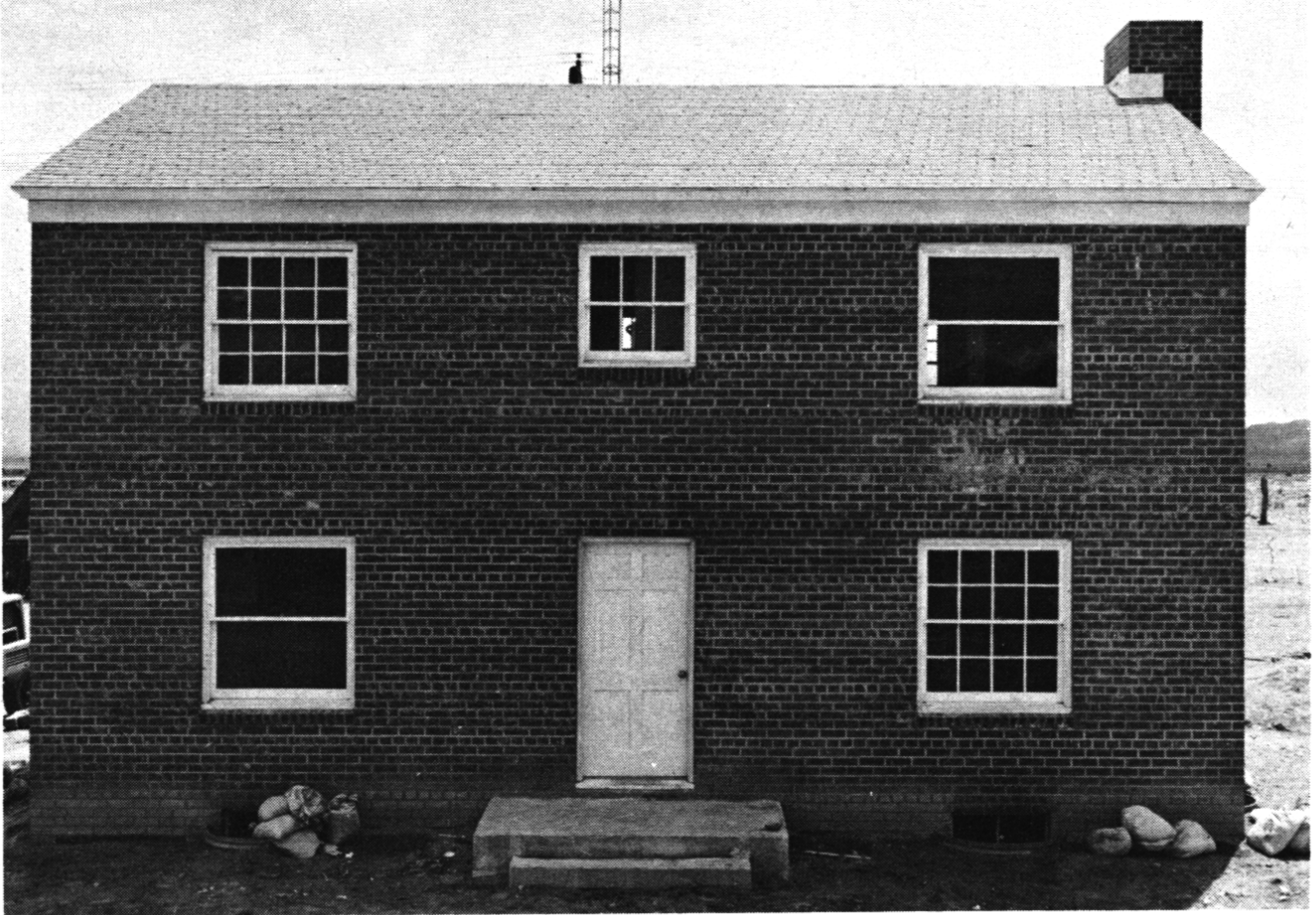
1 HA-11

House No. 1, from the camera tower from which the dramatic collapse pictures were taken. The Post Office truck to the left, although it lost all windows and suffered body damage, was driven away later, as was the car in the rear of the house. Entry to the basement was made through the corner at lower center. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)

LSA-2

3,500 feet from ground zero. The house overhead is totally destroyed, some of it has fallen into the basement, but the mannequin in the lean-to shelter is undisturbed. The photo was taken from ground level, looking into the basement through the gap between the basement wall and the broken floor timbers. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)



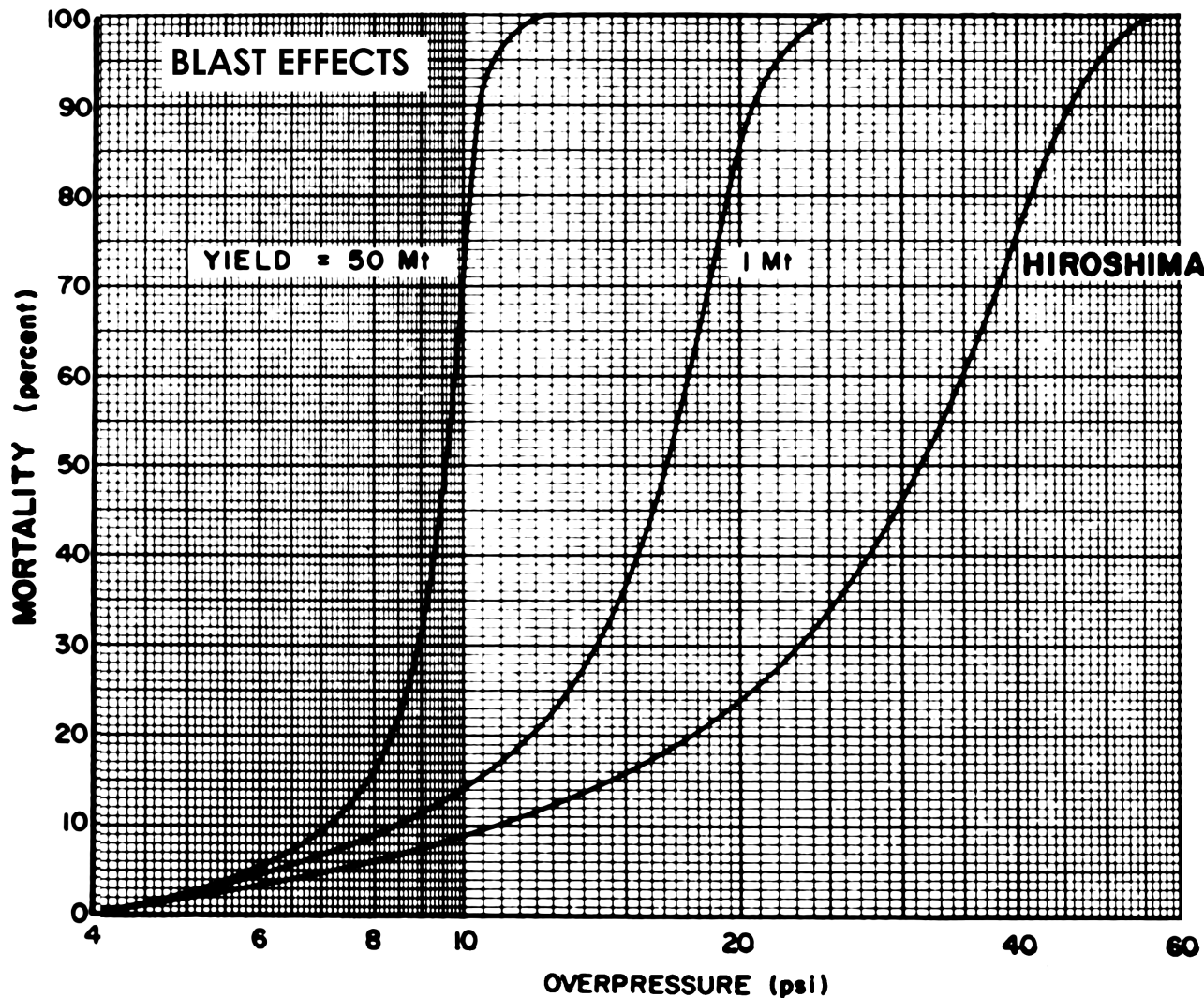


29 kt Teapot-Apple 2 test, 5 psi peak overpressure

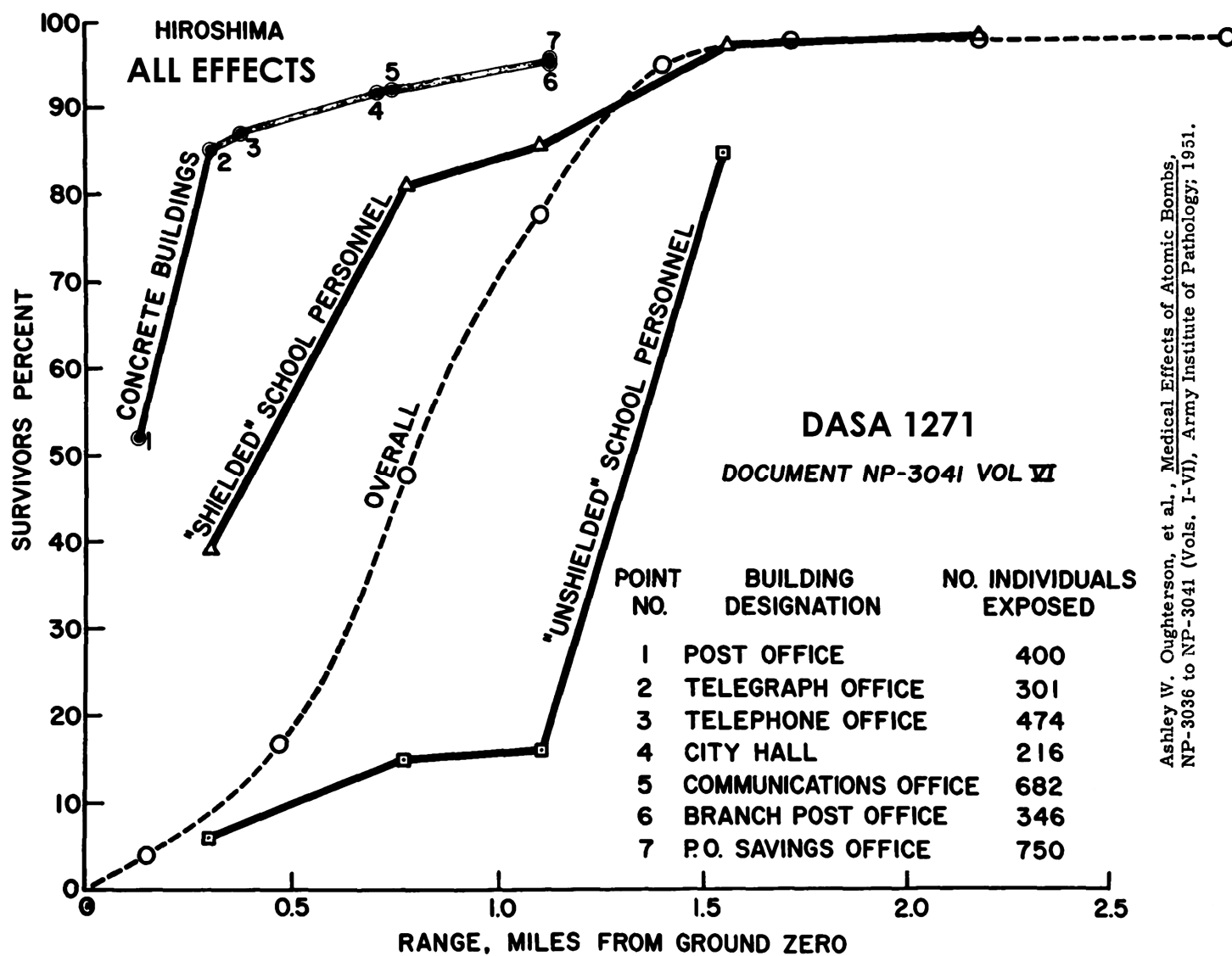
exterior walls were exploded outward, so that very little masonry debris fell on the floor framing. The roof was demolished and blown off, the rear part landing 50 feet behind the house.

S. Glasstone, Effects of Nuclear Weapons, 1964, p208
Wall brick debris was blown out, not in on to people!



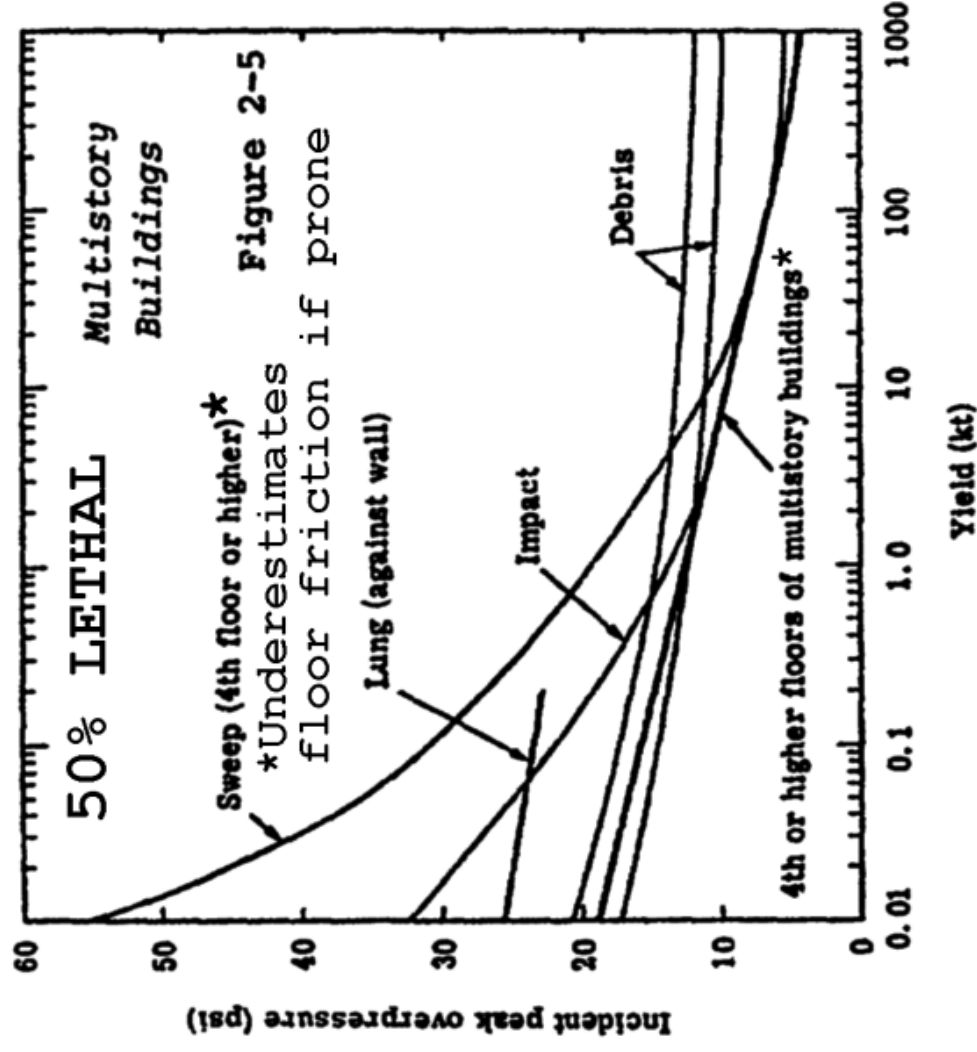
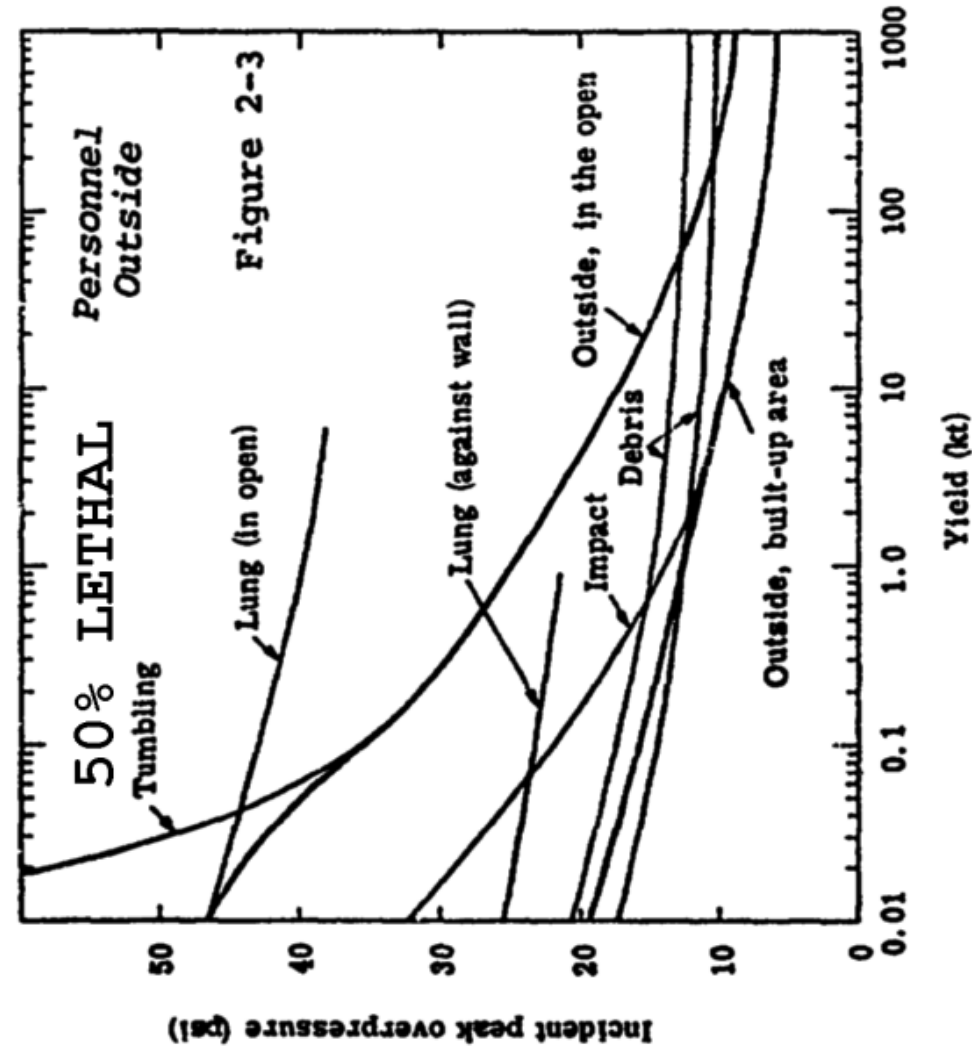


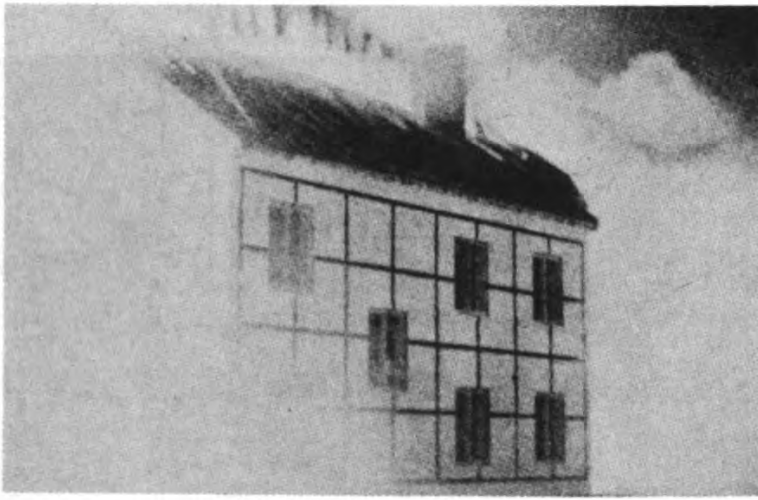
L. Wayne Davis, Donald L. Summers, William L. Baker, and James A. Keller, Prediction of Urban Casualties and the Medical Load from a High-Yield Nuclear Burst, DC-FR-1060, The Dikewood Corporation



Ashley W. Oughterson, et al., Medical Effects of Atomic Bombs, NP-3036 to NP-3041 (Vols. I-VI), Army Institute of Pathology, 1951.

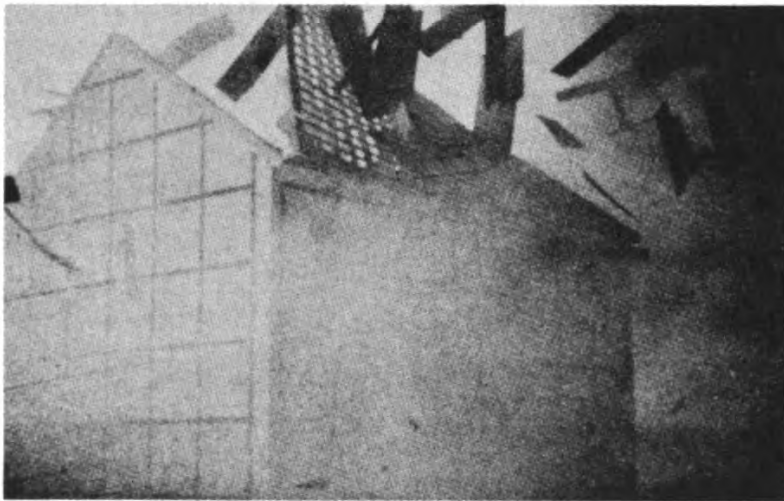
Dr Martin P. Fricke (Science Applications International Corp., California), "Preliminary Civilian Casualty Criteria for Low-Yield Nuclear Weapons," DNA-3547T, 1975.



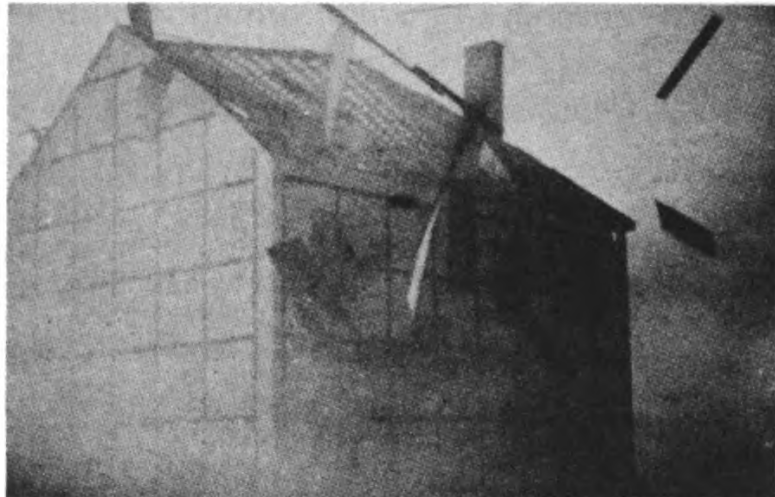


**47 kt Greenhouse
Easy, Eniwetok
Atoll, 1951. Brick
house, 3 psi peak
overpressure**

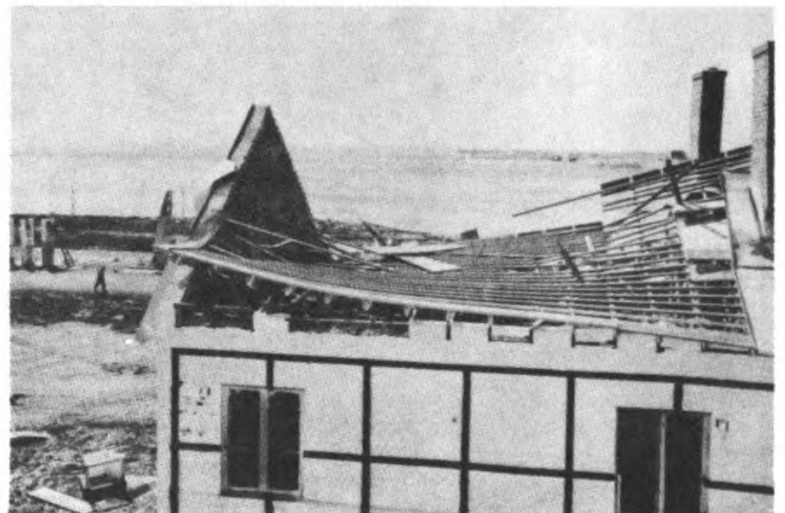
0.6 second



Impact + 1.0 second



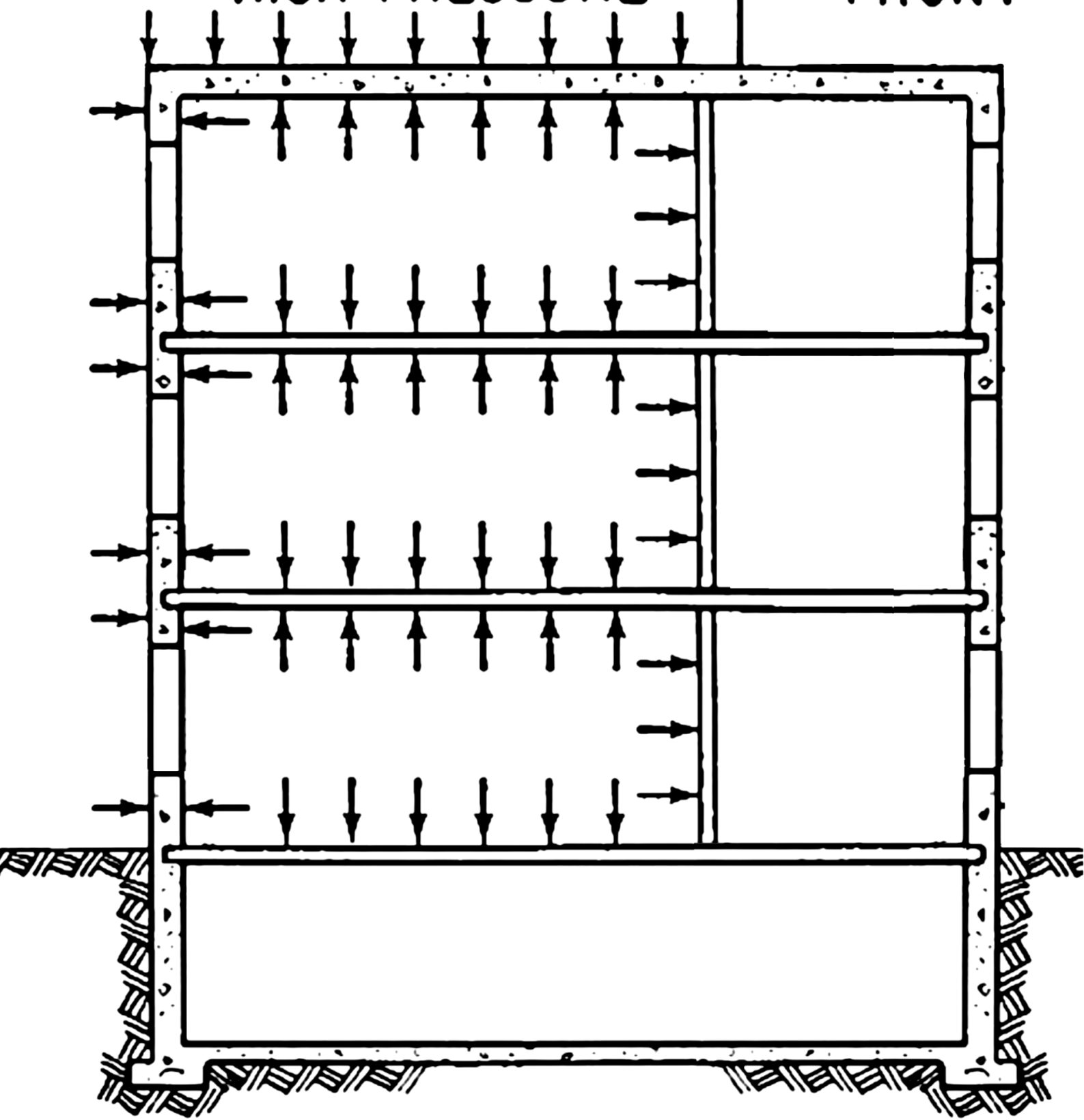
Afterward



Rapid equalization of inside and outside pressure for large window areas

**REGION OF
HIGH PRESSURE**

**SHOCK
FRONT**

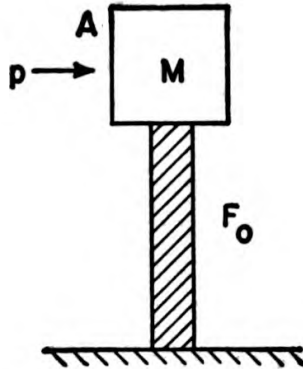


APPENDIX A¹

¹ By C. W. Lampson and S. B. Smith.

AN APPROXIMATE METHOD OF COMPUTING THE DEFORMATION OF A STRUCTURE BY A BLAST WAVE

Blast wave energy is absorbed, pushing a structure



$$M \frac{d^2x}{dt^2} = Ap - F_0$$

M is the mass of the structure, i. e., w/g ,
 F_0 is the resisting force of the structure,
 x is the deformation of the center of mass,
 A is the area of the front face,
 $p(t)$ is the effective blast pressure acting

After blast force below that of the resistance of structure, the building ceases to accelerate, and deflection effect is reduced as building returns to original position:

Resisting force, $F_0 = Mg +$ ground contact friction (anchoring of foundations)

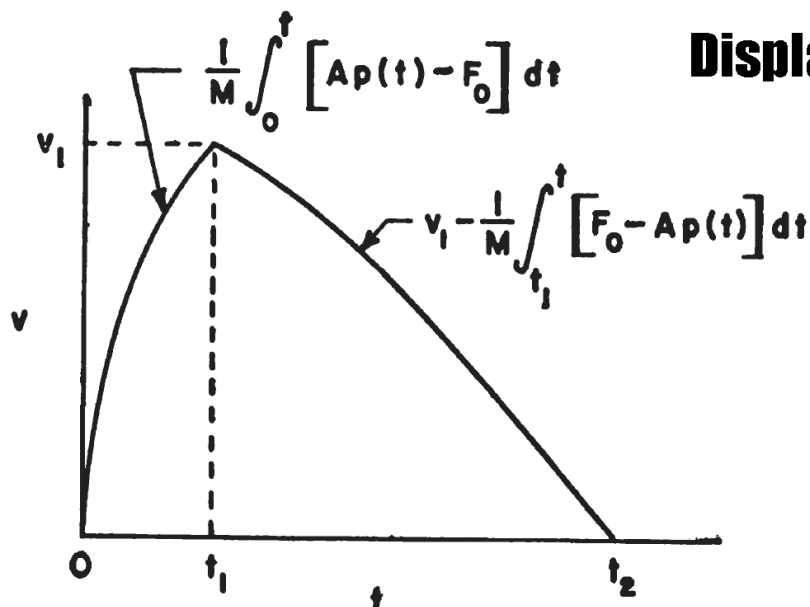
velocity $v_1 = \frac{1}{M} \int_0^{t_1} [Ap(t) - F_0] dt.$

Resisting force decreases if/when walls crack

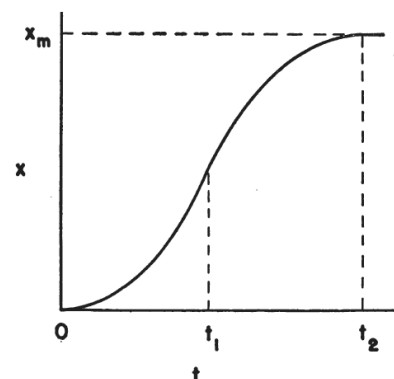
velocity $v = v_1 - \frac{1}{M} \int_{t_1}^t [F_0 - Ap(t)] dt.$

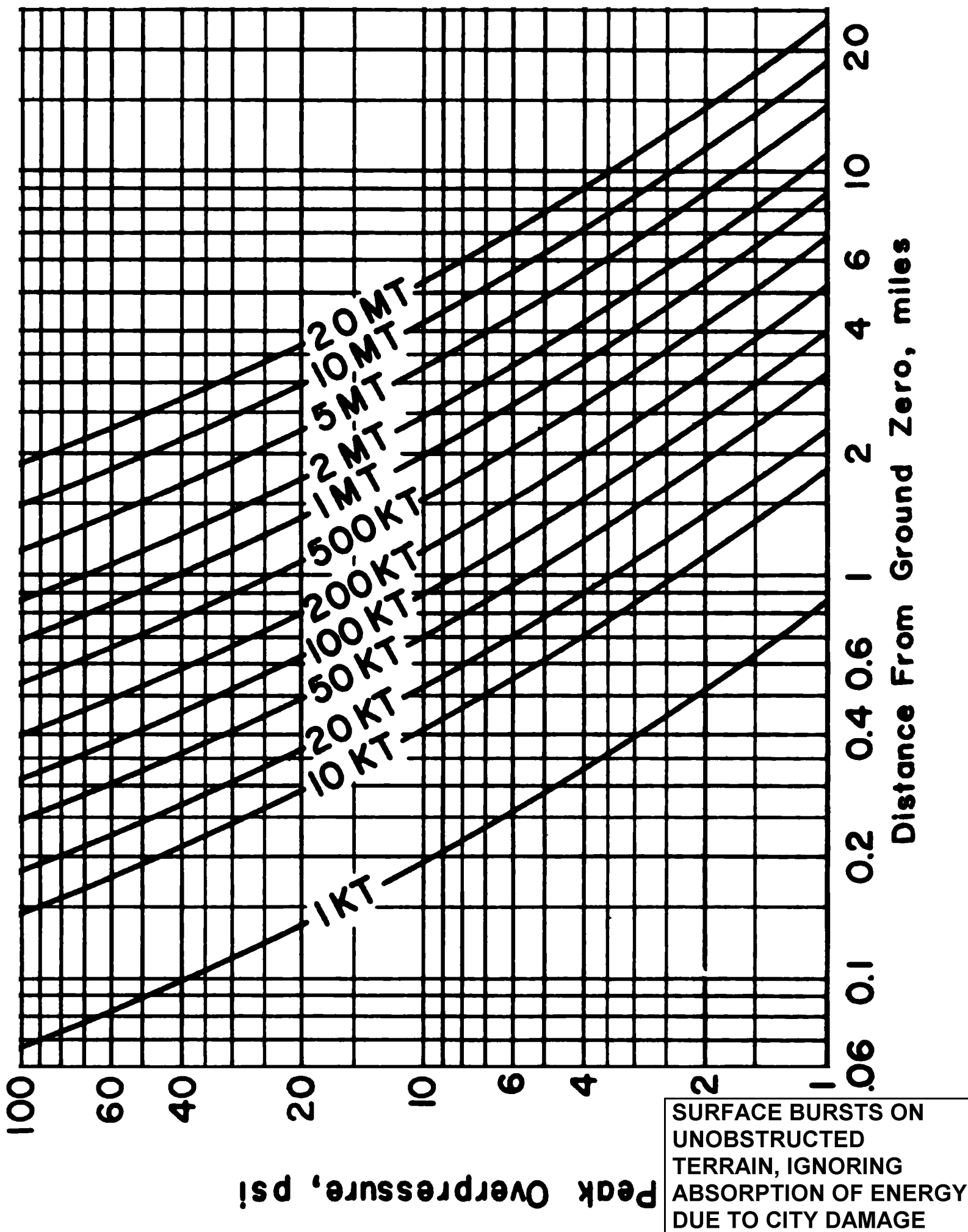
=> pressure resistance of wall = Mg/A

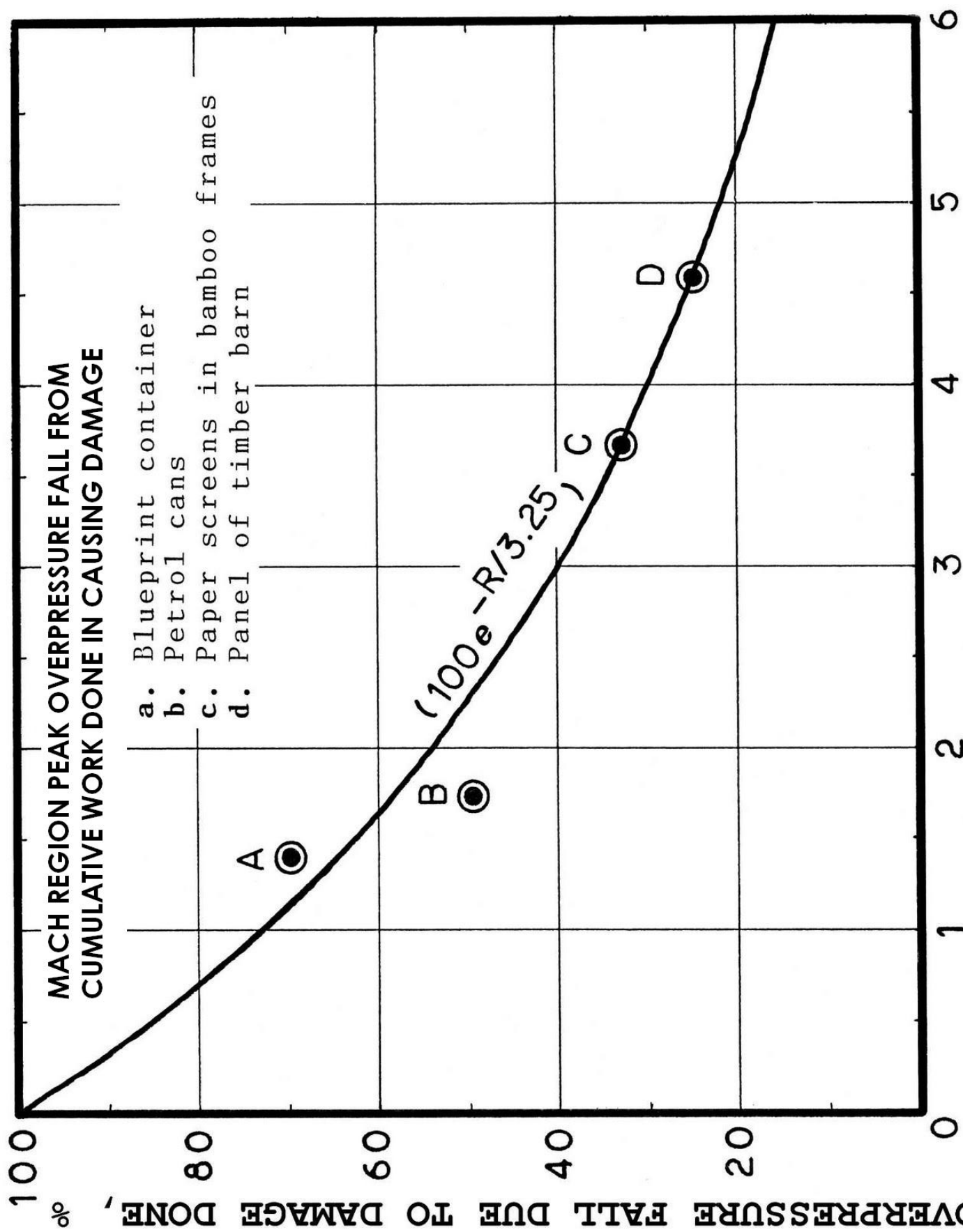
(ignoring ground friction and damage)



Displacement of centre of mass of building







DISTANCE FROM HIROSHIMA GROUND ZERO, KM

Data from Dr W. G. Penney, et al., 'The Nuclear Explosive Yields at Hiroshima and Nagasaki', Phil. Trans. Roy. Soc., v266 (1970), pp. 357-424.

DIAGRAM FOR SCALING BLAST DAMAGE

